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ORAL SURGERY
ORAL MEDICINE
and ORAL PATHOLOGY

EDITORIAL

THE EXTENSION OF ORAL PATHOLOGY

THE foundation of the American Academy of Oral Pathology by a small group of oral pathologists in 1946 and the considerable increase in its membership since then have had a significant impact on the development of the biologic aspect of dentistry in the United States.

Departments of oral pathology have been established in all American dental schools, with part-time or full-time professors directing the teaching and research on an undergraduate and graduate basis. In addition, in many institutions the department of oral pathology furnishes valuable diagnostic services.

We understand that in the dental schools of many countries the pathology is restricted to diseases of the teeth and does not include diseases, deformities, and tumors of the oral cavity, jaws, and associated structures. The preparation for the practice of the various dental specialties, such as oral surgery, oral medicine, periodontics, and orthodontics, without doubt must include the pathology of the involved areas, but also the general practitioner should be given a broad background in oral pathology so that he will be able to recognize or diagnose the various diseases of both local and systemic origin. It is this broadened concept of dentistry which, in the United States, has greatly raised the standard of the profession in the last decade.

The problem may be solved by the newly founded International Academy of Oral Pathology which met for the first time in New York in September, 1959. The Fellows of the Academy are Dr. Lester R. Cahn of New York, Major General Joseph L. Bernier of Washington, D. C., Professor Robert Bradlow of London, Professor Martin Rushton of London, Dean Reidar Sognnaes of Los Angeles, Dr. Jens Pindborg of Copenhagen, and Dr. Kurt H. Thoma. The first meeting was attended through special invitation by forty-one oral pathologists from ten countries, which is good evidence of the interest in the broader field of oral pathology and the scientific aspect of dentistry.

A letter just received from Dr. Lester R. Cahn, suggesting additional aims of the Society, is appended.

Last summer it was my great privilege to be the first guest lecturer appointed to the newly instituted Post-Graduate Courses of the Australian Dental Association. I lectured in Tasmania, Perth, Adelaide, Melbourne, Brisbane, and Sydney. Wherever I went I found a great interest in oral pathology.

All over the world the dental undergraduate receives instruction in dental pathology (rarely, however, in the broader domain of oral pathology). Upon graduation, continuing education in this subject ceases. Nonetheless, there are many who would wish to go on. The problem is, how can this be done?

One way is the formation of study groups. With the formation of such groups, where can material be obtained and, once obtained, who can demonstrate it for proper study?

A partial answer to these questions can be seen in an excerpt from a letter recently received from Tasmania: "I have gone into the suggestion that we form a study club in oral pathology and have discussed the proposition with Dr. Hamilton of the Pathology Department of the Royal Hobart Hospital. He was very much in favor of the idea and offered to lend us a collection of normal slides, microscopes, as well as the facilities of the department. He also promised to give us assistance in tutorship, should it be required."

This is a wonderful and generous start, and such cooperation with the pathology departments of hospitals, and possibly medical schools, can generally be obtained. However, more is needed. After the study of normal tissues comes the study of abnormal tissues on a broad scale, and then the study of abnormal oral tissues.

The first two studies can be arranged under the tutelage of the general pathologist. The last must have the advice and instruction of an oral pathologist. To acquire the service of a qualified oral pathologist may be difficult, but it does not present an insurmountable problem. It is in this realm that the International Academy of Oral Pathology can be of great aid, and I should like to make the following suggestions:

1. Sets of study slides of oral lesions should be prepared by the Academy. These can be accompanied by a description of the slides, photomicrographs of typical areas in each slide, the history, the clinical picture, and a roentgenogram of the lesions from which the particular slide was made, or a comparable one. Study sets so prepared are almost self-teaching.

2. Some type of financial aid should be provided, such as the payment of a teacher from the medical school or hospital who may be enlisted to give basic instruction in histology, pathology, etc.

3. An interchange of slides of interesting material with other groups throughout the world should be promoted through the establishment of an international clearinghouse.

Meetings at certain intervals should be arranged to discuss the progress of the groups, to present interesting cases, and to share the results of any research being done in various parts of the world.

The above is the new goal of the International Academy of Oral Pathology.

K. H. T.

OPERATIVE ORAL SURGERY

MIXED TUMORS OF THE PALATE

A Statistical Survey and Report of Two Cases

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MIXED tumors have been described as benign, frequently encapsulated growths which occur in the salivary glands, the mucosa of the oral cavity, and the palate. They have been reported in such unlikely places as the eyebrows, arms, and legs.[4]

It has been stated that mixed tumors of the salivary glands constitute about 5 per cent of all neoplasms of the oral cavity and about 2 per cent of all cancers in man. The term "parotid tumor," a name often applied to this growth, arises from the tumor's well-known predilection for that particular gland. Our review of 185 cases of mixed tumors operated upon at The Presbyterian, Woman's, and Eye and Ear Hospitals revealed that 143, or approximately 78 per cent, involved the parotid gland.

Although a much smaller percentage of these tumors were found in the hard and soft palate, they were nevertheless found at that site more frequently than any other tumors, except for the papillomas and fibromas. The abundance of glandular elements in the submucosa of the hard and soft palate accounts for the frequency with which these tumors are noted in that area. In our series of cases a total of fifteen such tumors (8.1 per cent) were found there. Of these fifteen cases, five presented histologic evidence of changes which were described as malignant and which required more radical surgery. (This number does not include the cases operated upon in 1958, as too little time has elapsed to permit any valid conclusions concerning recurrence and postoperative course.)

The problem of diagnosis of mixed tumors of the palate is not a particularly difficult one. Distinguishing the benign from the malignant growths, however,

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is another and much more elusive problem, which we will attempt to show in this article.

PATHOGENESIS

Speculation on the pathogenesis of mixed tumors of the salivary glands has covered a wide variety of theories, most of which have been logically eliminated. A few of these proposed theories are as follows:

1. *Embryonic theory:* Proponents of this theory believe that these tumors arise from embryonic remnants following formation of the salivary glands. It is thought that, because of a disturbance in the development of the branchial arches, these rudiments are enclosed and ultimately give rise to the tumor. This seems unlikely, according to Foote and Frazell,[17] ". . . since tumors identical in structure to many salivary gland mixed tumors occur in a wide variety of locations anatomically inconsistent with origin from such a source; for example, mixed tumors of sweat gland origin may be located anywhere from the soles of the feet to the vertex of the scalp."

2. *Mesenchymal theory:* This theory is based on the premise that these tumors arise from the fibrous stroma and capsule of the gland. However, it does not explain the presence of epithelial elements in the tumor except on the basis that they appear merely as vestiges of the original gland or through metaplasia of the fibrous tissue. Most critics dismiss this theory, for they feel that adult connective tissue is unlikely to undergo epithelial metaplasia.

3. *Ectomesodermal theory:* This explains these tumors as being formed from inclusions of ectodermal mesenchyme, which is thought by some to be present in the head and branchial arch region of the developing embryo. These cells have never been recognized, probably because of the fact that they do not exist or that they are indistinguishable from adult cells.

4. *Epithelial theory:* This is the theory which is generally accepted today. It states that these tumors arise from ectoderm of the primitive oral cavity. The stroma is thought to arise from a mucoid degeneration or secretion of epithelial cells or as a result of an organizing action of the tumor cells on the surrounding mesenchyme. Cahn[16] states: ". . . it is generally believed today that the mixed tumor is an epithelial growth derived from the epithelium of the glands, the various substances in it being the result of epithelial secretion or degeneration."

OCCURRENCE

Although mixed tumors have been reported to show certain sex tendencies, such reports have been invariably refuted and challenged. Gavin[1] states that these growths appear with equal frequency in both sexes. There does seem to

be a slight preponderance of female patients in our study, but our series of cases is quite small, precluding the establishment of any conclusive ratio (Table I).

The occurrence of mixed tumors outside the major salivary glands is worthy of mention in this article. These growths seem to be more common in the respiratory tree, although there are reports of mixed tumors of the eyebrow, cheek, and tongue. Martin[2] concludes that ". . . the palate is the site of origin of a greater percentage of benign mixed tumors of the salivary gland type than is any other structure of the head and neck, except the parotid salivary gland." We have noted, on the other hand, that mixed tumors appear with equal frequency in the submaxillary gland and in the palate.

It may be of academic interest to note that, as shown in our study, these tumors occur more frequently in the left palate than in the right and that they never appear in the midline, a clinical aspect which may serve to distinguish them from palatal tori.

Table I shows the age distribution of the fifteen cases studied. The age indicated is that at which the tumor was first noted by the patient. It is apparent from this table that no one age group is especially prone to mixed tumors of the palate. The earliest age at which the tumor was first observed was 12 years, and the oldest was 72. The average age was 40 years.

It is a well-known fact that these tumors show a distinct tendency to recur, especially following enucleation. At the time of their recurrence, they generally become locally destructive and invasive, arising from multiple foci. The tendency toward and the extent of recurrence are variable, depending on the time that has elapsed since the initial surgery, the completeness of the enucleation, and the degree of malignancy of the primary lesion. Of the five cases of malignant tumors reported here, three had recurred extensively; in each case the patient subsequently died of complications attributable to the growth. In the two remaining cases of malignant growths, it was impossible to acquire a follow-up report on one of the patients, and in the other only one and one-half years had elapsed since the time of surgery. Of the ten benign tumors, three had recurred, one patient ultimately requiring a hemimaxillectomy and exenteration of the orbit.

Local metastasis to the regional lymph nodes is uncommon unless the tumor is traumatized, as may happen when removal is incomplete. In such cases invasion of the regional lymph nodes is sometimes seen.

Recurrence following removal does not necessarily indicate malignancy. It should be remembered, however, that with each recurrence the tumor becomes more and more invasive, and the development of a carcinoma from a mixed tumor is conceivable.

DIAGNOSIS

When mixed tumors were first recognized as a clinical entity by Bilroth in 1859, they were described as slow-growing, painless, and often multiple and encapsulated. Very little more can be said today concerning the clinical appearance of these tumors.

TABLE I

CASE NO.	RACE	AGE*	SEX	PREOPERATIVE DURATION	SIGNS AND SYMPTOMS	DIAGNOSIS†	TREATMENT	FOLLOW-UP RESULTS‡
1	W	28	F	10 years	Painless mass in right palate with resultant ill-fitting denture	Benign mixed tumor with suggestion of local invasion	Enucleation	14 years—no recurrence
2	W	19	F	2 weeks	Painless mass in right palate	Benign mixed tumor	Enucleation	14 years—no recurrence
3	W	50	F	5 months	Asymptomatic mass in right palate	Benign mixed tumor	Enucleation	11 years—no recurrence
4	W	31	M	11 years	Removal of left palatal tumor one year following discovery; seven years following surgery swelling appeared over left side of nose; rapid growth recently, with ulceration	Malignant mixed tumor	Not resectable; radiation	11 years—patient died as result of tumor extension
5	W	52	M	2½ weeks	Asymptomatic swelling of left palate	Benign mixed tumor	Enucleation	9 years—no recurrence
6	W	35	F	2 years	Mass in left soft palate; tenderness in past four months	Benign mixed tumor	Piecemeal removal with cautery	7 years—no recurrence
7	W	23	F	3 years	Painless mass in left palate	Benign mixed tumor	Enucleation	7 years—asymptomatic recurrence; patient refuses treatment
8	W	30	F	4 years	Painless mass in left soft palate	Malignant mixed tumor	Enucleation	No follow-up available
9	W	72	M	2 months	Mass in left palate associated recently with some pain and ulceration	Benign mixed tumor	Piecemeal removal	5 years—patient died of other causes; no recurrence of palatal tumor noted

10	W	28	M	8 years	Painless, lemon-sized, fluctuant mass in right soft palate	Benign mixed tumor	Piecemeal removal	No follow-up available
11	W	12	M	47 years	Asymptomatic, orange-sized mass in left palate; extension into nasal cavity	Malignant mixed tumor	Excision	5 years—patient died as result of tumor with wide extension
12	W	20	F	—	Tumor of right palate unsuccessfully removed three times over past twenty years; tender mass on right palate associated now with nasal obstruction and roentgenopaque maxillary sinus	Benign mixed tumor	Right hemimaxillectomy	4 years—recurrence and extension into orbit
13	W	38	F	—	Asymptomatic mass of palate	Benign mixed tumor	Enucleation	4 years—no recurrence
14	W	66	F	1 month	Asymptomatic mass in left soft palate	Malignant mixed tumor	Enucleation	20 months
15	N	53	F	15 years	Removal of mass in left soft palate followed one year later by progressive weight loss, facial paralysis, and pain; ulcerated lesion in left soft palate	Malignant mixed tumor	No treatment except relief of symptoms	2 years—patient died as result of extensive invasion and metastasis to regional lymph nodes

*Age when patient first noticed tumor.
†All diagnoses confirmed by histologic sectioning.
‡Years noted represent time since original surgery.

A presumptive diagnosis of benign mixed tumor of the palate may be made when a well-circumscribed, slow-growing, asymptomatic mass with a tendency to extend toward the pharynx is encountered. The tumor is usually a firm but movable mass in which occasional soft, fluctuant areas may be palpable. The degree of firmness depends upon the relative amounts of mucoid and cartilaginous material present in the tumor.

Although cartilage in many of these tumors had been noted before, it was not until 1863 that Virchow first reported the presence of bone in a small percentage of these growths. The presence of bone or cartilage, per se, in these tumors has often been questioned. Many believe that, instead of true cartilage, this is a hyalinized substance which the epithelial cells form and with which they surround themselves and thereby simulate the appearance of cartilage.

Often the surgeon may find himself at a loss to clinically distinguish a mixed tumor from such entities as cysts, abscess cavities, osteomas and other neoplasms, and palatal tori. In most of these instances, careful scrutiny of diagnostic roentgenograms and vitality tests to the adjacent teeth will rule out various possibilities, but generally it will be necessary to perform a biopsy in order to firmly establish the diagnosis and character of the mixed tumor.

Microscopically, the mixed tumor presents a problem unlike that presented by pure epithelial tumors, such as adenomas and carcinomas. The origin and classification of the latter neoplasms can be easily determined from a histologic standpoint. Mixed tumors, on the other hand, present a variety of appearances, one particular tumor being entirely different from another. This lack of conformity may even be noted in different areas of the same growth. The tremendous variations in the appearance of these tumors arises from the configuration and relative proportions of the various structural elements composing the growth, that is, epithelium, fibrous connective tissue, myxomatous tissue, cartilage, and/or bone. The epithelial portion of the growth itself presents a variety of patterns, ranging from strands or sheets to something closely resembling the structure of small glands.

In most areas of the oral cavity it is relatively easy to distinguish malignant from benign lesions, but in the palate such a distinction is often impossible. In attempting to distinguish the malignant from the benign growths, one should be suspicious of a tumor which, after a long period of quiescence, has recently exhibited a rapid increase in size. An ulcerated mass should also lead one to suspect that the tumor has undergone malignant transformation, although, as shown by the two cases reported in this article, such is not always the case.

The final diagnosis of the benign and the malignant forms can be positively made only after microscopic examination. The tremendous variation of structure in different portions of the same tumor has prompted many surgeons to question the value of biopsy in these growths. From the standpoint of definitive diagnosis, however, a biopsy has unquestionable merit, for benign and malignant tumors present different problems of therapy. An erroneous diagnosis may prove disastrous.

Malignant mixed tumors present two features: (1) the structural elements of the benign growth and (2) malignant changes in isolated areas, that is, areas which exhibit structural elements usually associated with metastases.

Many authors feel that biopsy of these tumors may even be dangerous and is, therefore, contraindicated. Cheyne and associates[3] state that when tissue is removed for biopsy the capsule of the tumor is broken, which permits the spread of tumor cells. Montreuil[4] feels that biopsy is not recommended unless the tumor is ulcerated. Gavin[1] asserts that biopsy of these tumors is not reliable because of the tremendous variations in different portions of the same tumor.

Heflich and Volk[5] report that in personal communications Kurt Thoma, Theodor Blum, and J. L. Bernier all favored biopsy of mixed tumors.

Shira[18] seems to have solved the problem by the use of excision biopsy. He recommends complete excision of these tumors, including the overlying mucosa. The entire mass is then submitted, and serial sectioning reveals the presence of any malignant areas. Following the diagnosis of malignant mixed tumor, a second and more radical procedure is performed, this time to include bone and other structures adjacent to the tumor site.

TREATMENT

The treatment of choice in all cases of mixed tumor of the palate is surgical excision, the extent of which depends upon the degree of malignancy of the growth. In all cases the overlying mucosa should be excised with the growth. Cahn[16] presents a most thought-provoking series of facts. He states that in many instances it is impossible to determine histologically the line of demarcation between the capsule of the tumor and the overlying submucosa. If this difficulty presents itself under the microscope, it is inconceivable that the capsule can be readily identified at the time of surgery. Since tumor cells have been shown to appear in the capsule of the tumor, any remnant of this capsule which is overlooked at the time of surgery may subsequently become a nidus for a recurrent and more invasive growth. Many times, upon close examination, this capsule is seen to have projections which invade the surrounding tissue. It is likely that any of these excrescences left behind at the time of surgery may be responsible for the numerous recurrences noted.

The use of postoperative irradiation has also become a debated issue. Charache[12] states that, in view of the questionable carcinogenic effect of radiotherapy, one should hesitate to prescribe radiation for children with nonmalignant conditions of the head and neck. This statement may be compared with that of Patey,[8] who feels that preoperative irradiation of these tumors is beneficial, since it causes the tumor to shrink and a dense fibrous capsule to form, thereby leading to an easier surgical procedure. Postoperatively, radiotherapy is advised for recurrent tumors which, presenting greater malignant changes, become more and more radiosensitive.

CASE REPORTS

CASE 1.—The patient, a 47-year-old Negro woman, was in apparent good health except for marked obesity. Approximately ten years prior to her present admission, the patient first

noted a growth on the right side of the palate when, upon traumatizing the area, she began to hemorrhage. She visited the outpatient clinic of the University of Pittsburgh Medical Center, where the growth was excised. No biopsy specimen was submitted at that time. The patient was instructed to return to the clinic if the growth ever caused her any discomfort or if the area began to hemorrhage again. Since these symptoms never recurred, the patient sought no further treatment. Two months prior to her admission, she visited a dentist for some necessary extractions. The dentist noticed the recurrent tumor and refused any further care until the nature of the growth was determined. The patient returned to the outpatient clinic, where she was referred to The Presbyterian Hospital for further evaluation and treatment.

The patient stated that the growth, at the time of her admission, had attained its largest size following a long period of steady expansion. Except for the brief episode of hemorrhage ten years before, the growth had been totally asymptomatic and had caused no impairment of mastication, speech, or swallowing.

The past medical history and systemic review were essentially negative except for the finding that the patient was prone to acute attacks of asthma, especially during the first two weeks of July.

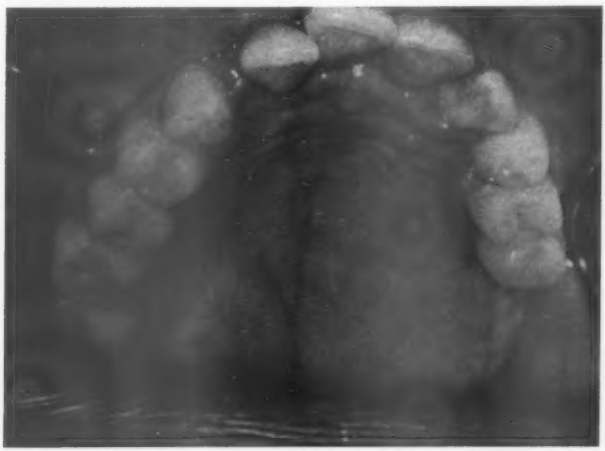

Fig. 1.—Photograph of benign mixed tumor. Note small ulceration opposite maxillary right second molar.

Examination.—A growth was noted on the right side of the palate, extending from the distal aspect of the maxillary first molar onto the soft palate and from the lingual gingival margin to the midline of the palate (Fig. 1). The surface of the growth was surmounted by two ulcerated areas measuring approximately 2 mm. in diameter. The growth itself measured approximately 2 by 3 cm. and had a sessile type of base. No pus or other fluid substance could be seen escaping from the ulcerated areas. Although the mass was firm, some areas of softness and fluctuation were noted. A parulis was also seen in the patient's mouth opposite the left mandibular first and second molars. There was no evident regional lymphadenopathy.

Roentgenographic Examination.—All roentgenograms studied failed to indicate any abnormal findings.

Laboratory Examination.—All of the laboratory examinations were within normal limits. These included hematology, blood chemistry, and urinalysis.

Treatment and Hospital Course.—On Aug. 22, 1958, the patient was brought to the operating room where, under infiltration anesthesia, a biopsy of the palatal tumor was performed. The pathologic report indicated a benign mixed tumor.

Four days later the tumor was totally removed. The patient was anesthetized with intravenous thiopental sodium supplemented with endotracheal nitrous oxide-oxygen. The perioral tissues were prepared with a synthetic detergent, and the patient was draped in a sterile manner. An incision, extending from the distal area of the right maxillary tuberosity to the mesial aspect of the maxillary left cuspid, was made, and the palatal mucosa was reflected. The greater palatine vessels were identified and ligated. The underlying tumor mass was thus exposed and removed in sections. The maxillary right first and second molars, which were periodontally involved, were also extracted at this time. The operative site was then thoroughly débrided of all bone spicules. The palatal flap was repositioned and fixed in position with 00 black silk interrupted sutures. The patient tolerated the procedure well and left the operating room fully reacted and in satisfactory condition.

Pathologist's Report.—Grossly, when reconstituted, the specimen measured approximately 2.5 cm. in diameter. It consisted of several pieces of firm, yellowish pink to gray myxoid tissue. Microscopically, the tumor was made up of a hyaline to myxoid stroma in which there were small cords of cuboidal and stellate cells. The histologic diagnosis was benign mixed tumor of salivary glands of the palate.

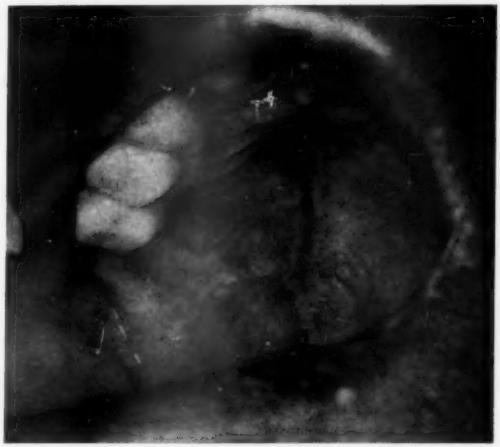

Fig. 2.—Postoperative photograph taken five months after surgery.

Postoperative Course.—Following the surgery, the patient's course was complicated by a head cold which was treated symptomatically. Three days after the operation an area of necrosis was evident on the palatal flap. This area increased in size until it measured approximately 4 cm. in diameter. One week postoperatively, areas of granulation tissue could be noted where the palatal tissue had formerly sloughed off.

On September 1 the patient was returned to the operating room where, under block anesthesia, the left mandibular first and second molars were extracted.

The patient was discharged on the tenth day following removal of the palatal tumor, and she has since been followed on an outpatient basis. The operative site has healed completely, with no evidence of tumor recurrence to date (Fig. 2).

CASE 2.—The patient, a 35-year-old well-developed, well-nourished white man in apparent good health, was referred to the Oral Surgery Department of The Presbyterian Hospital

for treatment of a mass of the left palate, diagnosed as a benign mixed tumor. He was admitted to the hospital on Nov. 3, 1958.

History of Present Illness.—Approximately two years prior to the present admission, the patient visited his dentist for the extraction of a tooth which had been causing him some distress. The dentist noticed the mass in the left palate and thought that it was due to abscess formation on an impacted third molar. An unsuccessful attempt at incision and drainage was performed. Following this, the patient ignored the mass, since it was asymptomatic. In June, 1958, the patient visited another dentist's office, again for extraction of a troublesome tooth. This dentist, upon noticing the mass, referred the patient to a general surgeon in Pittsburgh who, in turn, referred him to us for treatment.

The tumor was totally asymptomatic and, according to the patient, had never increased in size since its initial discovery. Conversation with the patient's family physician, however, indicated that the tumor had increased approximately one and one-half times in recent months. Past medical and surgical history and a systemic review were essentially negative.

Intraoral Examination.—A large mass was noted on the left portion of the hard palate, extending well back onto the soft palate (Figs. 3 and 4). It measured 4 by 3 by 3 cm. No ulcerations could be noted on the overlying mucosa. The mass appeared movable and soft in some areas, although palpation revealed some evidence of firmness in isolated areas.

The remaining teeth of the maxilla had some carious lesions and were very mobile. The entire oral cavity gave evidence of poor oral hygiene. The gingival tissue was slightly inflamed and edematous because of a periodontal condition. No regional lymphadenopathy could be noted.

Laboratory Examination.—All laboratory studies, including blood chemistry, hematology, and urinalysis, were within normal limits.

Roentgenographic Survey.—No evidence of bony destruction could be noted from the roentgenograms examined. However, there was a thickening of the maxillary antral lining. The remaining paranasal sinuses appeared free of pathology.

Hospital Course.—Four days following admission, the patient was taken to the operating room. Following administration of intravenous thiopental sodium combined with nasal endotracheal nitrous oxide-oxygen anesthesia, he was prepared with a synthetic soap solution and draped. A biopsy of the anteromedial aspect of the tumor was performed and submitted for frozen section. The remaining maxillary teeth were extracted, and a maxillary alveolectomy was performed while the pathologist's report was being prepared. This report indicated that no tumor tissue could be noted on the section, whereupon a second biopsy specimen, taken from the lateral portion of the mass, was submitted. The pathologist's report on the second specimen indicated adenocarcinoma. Following this report, the operative procedure was concluded and the patient was returned to his room.

A consultation request was immediately placed for consideration of a left maxillectomy. Prior to the time that this maxillectomy was performed, there were noted several palpable cervical lymph nodes which had not been detected at the time of the patient's admission physical examination.

One week following the biopsy procedure radical surgery was performed. First, a biopsy specimen of the cervical lymph nodes was removed and submitted for frozen section. The pathologist's report indicated that the nodes were benign, thus precluding the need for a radical neck dissection. The external carotid artery was ligated 1 cm. above the bifurcation, just below the course of the hypoglossal nerve. A Weber-Fergusson incision was made on the left face, and the skin flap was reflected onto the cheek. The infraorbital vessels were exposed and left intact. With an electrosurgical knife, an incision was made in the oral mucosa, completely encircling the tumor mass and extending into the buccal alveolar sulcus, which was incised with a knife. The maxilla was split anteriorly with a chisel, and the lower half of the maxilla, including the tumor mass, was removed in toto. Additional pieces of the soft palate were removed with the specimen to ensure a sufficiently wide margin of

resection. Hemostasis was accomplished by chromic catgut sutures and electrocoagulation. Closure of the soft tissue was possible without application of a skin graft. With 0000 chromic catgut sutures the buccal mucosa was approximated to the maxillary sinus and the superior and inferior edges of the soft palate. The lip and cheek incisions were closed with 0000 chromic catgut and 000000 silk sutures. A pressure dressing was applied to the operative site, and the patient left the operating room in satisfactory condition.

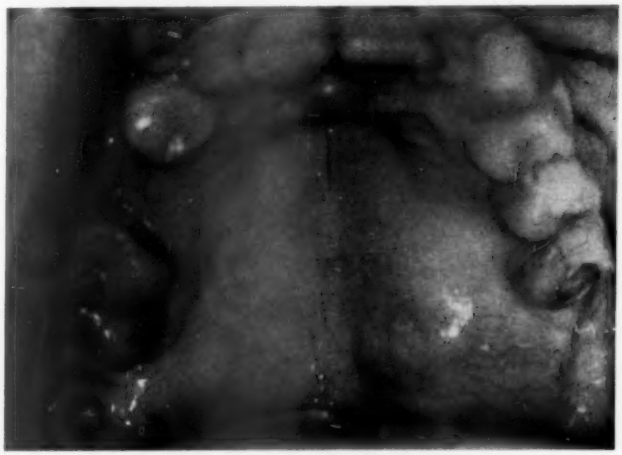

Fig. 3.

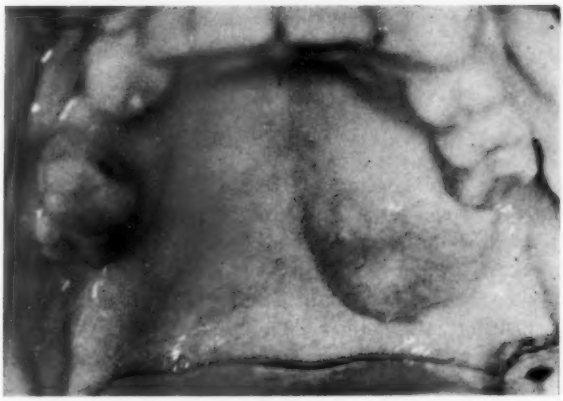

Fig. 4.

Figs. 3 and 4.—Photographs of malignant mixed tumor.

Pathologist's Report.—Grossly, the specimen consisted of a block dissection of the palate and floor of the nose in which there was a discrete, firm, yellowish pink mass measuring 3.5 by 3.0 by 2.5 cm. The overlying mucosa was intact except for the previous biopsy site.

Microscopically, the tumor was made up of small, solid cords and glands lined by round to oval cells. The supporting stroma was chiefly fibrocollagenous tissue. Although its margin was generally distinct, infiltration of tumor cells was seen among the remaining mucous and

serous glands in the palate. Toward the surface of the tumor the cells were large and somewhat pleomorphic. In these areas, mitoses averaged one for every four or five high-power fields. The pathologic diagnosis was malignant mixed tumor of the salivary glands of the palate.

Postoperative Course.—On the day following the operative procedure a Levin tube was introduced, and the patient was fed through it for one week. When the tube was removed at the end of this time, the patient was able to swallow with little difficulty. The remainder of the postoperative course was uneventful, and the patient was discharged from the hospital on November 19. He has been followed on an outpatient basis. Plans are being made for a prosthetic appliance to fill the operative defect, and these will be carried out shortly (Fig. 5).

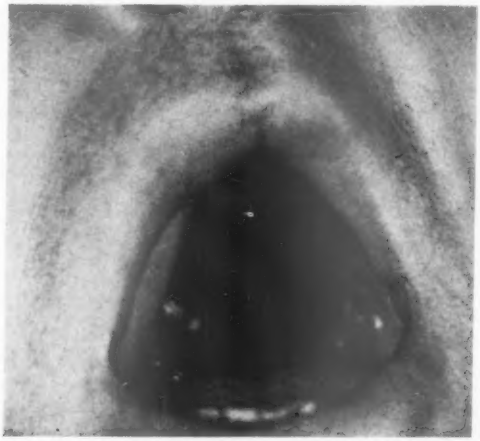

Fig. 5.—Photograph taken four months after surgery, showing operative defect resulting from hemimaxillectomy. Function has been restored with a prosthetic appliance.

SUMMARY AND CONCLUSIONS

Table I presents a summation of the statistical data which we were able to compile from the fifteen cases studied at these hospitals over the past fourteen years. In each of these cases, which constituted 8.1 per cent of the total number of cases reviewed, mixed salivary gland tumors of the palate were diagnosed, the diagnoses being confirmed by the Department of Pathology. Current follow-up information, where obtained, was acquired from the patient's dentist or physician or through direct communication with the patient.

An attempt has been made in this article to emphasize the importance of biopsy in the diagnosis of tumors of the palate. Because of the great clinical similarity of the benign and malignant forms of mixed tumors, this method of positive diagnosis remains the only absolute means of isolating one from the other. Although it has been written before that ulcerated tumors may be considered malignant, the cases reported in this article emphasize the fallacies of this statement. The case in which the ulcerated areas were noted proved to be benign, whereas the second, less sinister-appearing mass proved to be the malignant one.

The fact that these tumors recur, with occasionally disastrous results, is emphasized in this article. This indicates the need for initial total excision, which is the treatment of choice. This total excision should include also the overlying mucosa in order to remove any possibility for capsular remnants to serve as nidi for subsequent recurrent tumor masses.

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REPLANTATION OF AN UPPER CENTRAL INCISOR IN A PRETRAUMATIZED AREA

Report of a Case

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REPLANTATION of fully formed teeth from both the anterior and the posterior regions has been described in the dental literature. Replantation, however, is usually restricted to the anterior teeth and employed as emergency treatment following trauma which has resulted in partial or complete avulsion of the tooth. Limitation of the use of this procedure is due to the fact that replanted teeth undergo vigorous resorption and osseous replacement, which cause complete loss of the root and subsequent shedding of the crown.

Although the true nature and cause of this resorptive phenomenon are not known, it occurs in almost all cases, experimental as well as clinical. Several factors can be outlined as possible causes: (1) the vitality of periodontal ligaments and/or cementum, (2) the presence or absence of root canal treatment, (3) the amount of trauma prior to or during the operation, and (4) premature pressure points following the reinsertion (premature occlusal contact, pressure due to uneven ligation, secondary infection, etc.). It is interesting, however, to see in the report of Lenstrup and Skieller[4] that after six years of observation, no radiographic evidence of resorption was seen in four out of forty-six cases of replanted upper anterior teeth.

According to Hammer[2, 3] and Axhausen,[1] resorption and osteogenic replacement are inevitable, and resorption advances much faster in teeth with scraped-off periodontal tissue than in those without. These authors demonstrated that the periodontal membrane acts as a protective shield against resorption in teeth that have not been subjected to periodontal scraping; it is possible to observe histologically that the early stages of resorption are initiated over the root areas from which the periodontal ligaments are accidentally plucked away during extraction. Therefore, in order to guarantee a considerable length of time against the final fate of resorption, replantation should be carried out with as little trauma as possible, and root scraping should not be practiced.

From the Walter G. Zoller Memorial Dental Clinic, the University of Chicago.

CASE REPORT

The patient, a 21-year-old white woman, was referred to the emergency service of the Zoller Dental Clinic on Dec. 6, 1958, for treatment of the upper left central incisor, on which she had fallen while playing basketball (Fig. 1).

Clinical, oral, and x-ray examinations revealed a loose, painful, lingually dislodged upper left central incisor which was extruded 4 to 5 mm. The gingivae around the tooth were slightly traumatized, and there was a slight oozing of blood. No radiographic indication of dental or alveolar bone fracture was found (Figs. 2 and 3). Blunted roots in the anterior dentition were observed radiographically, and the patient was questioned concerning the retained | III and the root resorption in the 1 | 1 2 III areas. It was discovered that about six years earlier an anteropalatally impacted upper left canine had been extracted. Loosening of the teeth and resorption had immediately followed the extraction, but within six months these symptoms had completely subsided. During this period the patient had no other symptoms and experienced no pain.

The patient had a slightly anterior open-bite, which was caused by a tongue-thrust habit. There was slight bilateral crowding in the lower premolar regions. Oral hygiene was excellent; the oral and pharyngeal mucous membranes were free of inflammation. The patient had no systemic disorders, and she was anxious to keep the tooth if it could possibly be saved.

Fig. 1.—Preoperative clinical view. Note oozing of blood and lingual dislodgment of the upper left central incisor.

Since the patient was very cooperative and aware that her case was not ideal because of the excessive root resorption already present and the marked root canal obliteration, it was decided that a replantation should be tried.

Following the usual preparation of the mouth, the area was anesthetized with a 2 per cent infiltration of Xylocaine. Following a circumferential undermining from the gingival attachment, the tooth was easily extracted and the patient was instructed to bite gently on a large piece of gauze. The patient's head was tilted slightly backward, and a saliva ejector was inserted through the space between the posterior teeth. The tooth was held in a piece of gauze which had previously been saturated with Ringer's solution, and the tooth and gauze were frequently dipped into the sterile solution. Access to the root canal was gained in the usual manner. Assorted engine-driven reamers were used to enlarge the canal. This procedure was followed by irrigation, drying, and insertion of crown-and-bridge cement by means of an engine-driven root canal filler. A gutta-percha cone of the proper size was seated, and periapical trimming and polishing were performed with a green stone. Blood clots were removed by irrigation of the socket, and the tooth was replanted.

For stabilization, an orthodontic 0.007 inch stainless steel wire was used in a very simple manner, and the area was covered buccally and lingually with a presqueezed zinc oxide and eugenol paste to reduce the salivary contact (Figs. 4 and 5).

The patient was given prophylactic intramuscular injections of penicillin on the day of the operation and for two days thereafter. No postoperative development of swelling, pain, or any other disturbance was evident.

Fig. 6 shows roentgenograms taken after one week, two weeks, three months, and ten months. As can be seen in Fig. 6, *B*, resorption in the periapical area developed within

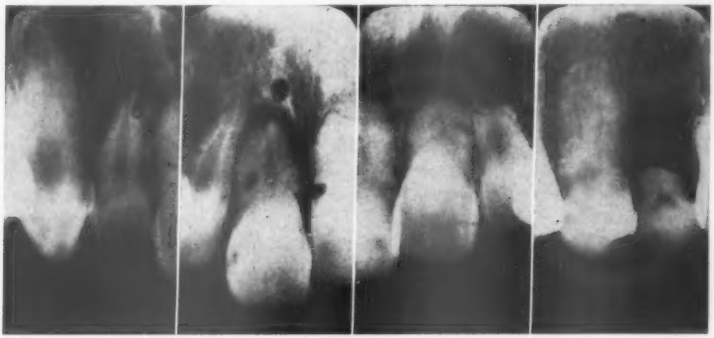

Fig. 2.

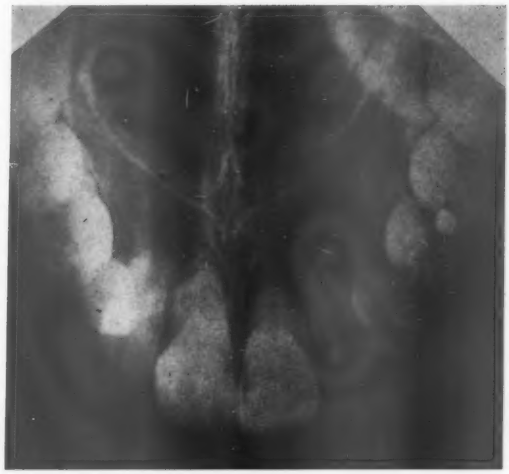

Fig. 3.

Figs. 2 and 3.—Preoperative intraoral and occlusal radiographic views of the area. Note marked resorption from the previous trauma, retained deciduous upper right canine, and marked root canal obliteration of the upper incisors.

fifteen days, suggesting an overextended root canal treatment. Fig. 6, *C* shows further-progressed resorption involving the middle lateral border of the root in several points. In Fig. 6, *D* the root has attained a rugged appearance. At present this replantation is clinically asymptomatic and successful. On the basis of the radiographic evidence, however, complete root resorption and osteogenic replacement are expected to occur in the future. This is the usual prognosis in cases of replantation.

Fig. 4.

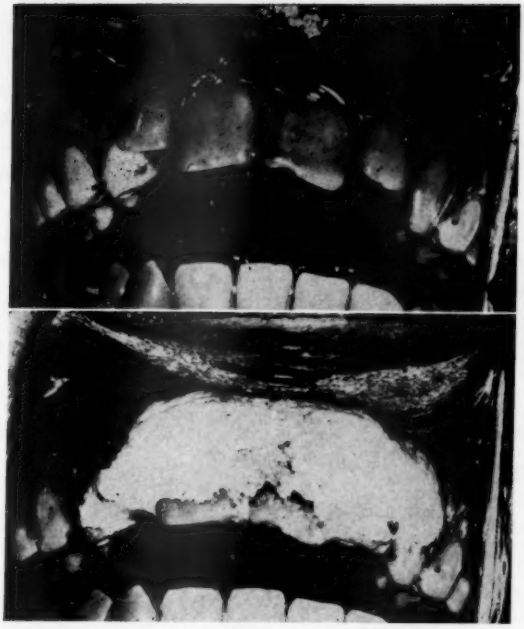

Fig. 5.

Figs. 4 and 5.—Simple wiring was carried out immediately after replantation, and presqueezed zinc oxide–eugenol dressing was applied to the anterior dentition.

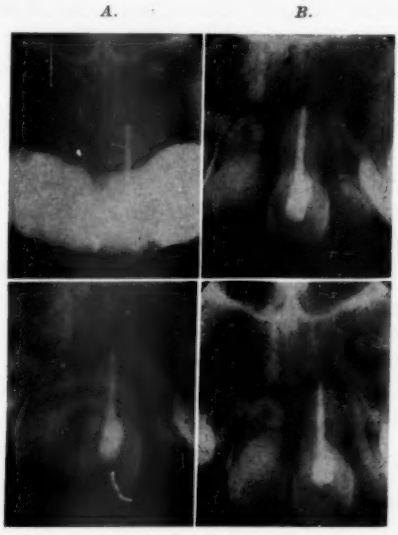

Fig. 6.—Roentgenograms taken at various times following the replantation. *A*, One week following surgery; no evidence of resorption can be seen. *B*, Fifteen days after surgery; initial resorption can be seen at the apex, and the root canal treatment has an overextended appearance. *C*, Three months after surgery; resorption is more advanced, and new resorption areas can be seen developing in the middle lateral border of the root. *D*, Ten months after surgery; resorption is still more advanced, and the root has a rugged appearance.

SUMMARY AND CONCLUSIONS

A clinically successful case of replantation in a pretraumatized area is described. In spite of the previous root resorption which had taken place six years earlier following the extraction of an impacted upper left canine, the tooth was successfully reinserted. Resorption and replacement by osseous tissue, however, started within a short period of time; these processes were detected radiographically as early as fifteen days following the operation. The fact that the first area of resorption was in the trimmed and polished periapical area is further evidence of the protective importance of the periodontal membrane, as previously claimed by Hammer[2, 3] and Axhausen.[1]

Fig. 7.—Clinical view after three months. The tooth is firm with normal gingival attachment. No discoloration is present, and it is impossible to distinguish the replanted tooth. Note slightly anterior open-bite caused by a tongue-thrust habit.

Assuming that the vitality and integrity of the periodontal membrane are the most important determining factors in postponing the resorptive phenomenon, it is important that the whole operation of replantation be carried out gently and quickly, under sterile conditions, and with as little trauma as possible. The length of the working period can be minimized by the use of engine-driven root canal reamers and fillers. In order to avoid mechanical and chemical trauma, the tooth should be seized by gauze saturated in Ringer's solution or saline solution. Also, postoperative stabilization should be practiced, and a surgical cement coating should be used.

In conclusion, in either a preselected or an emergency case, if the patient is willing and understands the temporary nature of the results of the operation, replantation is both functionally and esthetically desirable and may be used instead of extraction.

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THE INCIDENCE RATE OF JAW SARCOMAS IN DENMARK, 1943 TO 1953

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Most of the investigations dealing with sarcomas of the jaw are based on case reports. Only a few represent a considerable number of cases (for example, the investigations by Schmidt,[9] Scudder,[10] Geschickter,[5] Ringertz,[8] Sherman and Melamed,[11] and Kragh and co-workers[6]). A separate group of these tumors, consisting of the jaw sarcomas occurring among African children, has been reported by Burkitt,[1] and Laffargue and Gardel.[7]

So far as I have been able to ascertain, no attempts have been made to estimate the incidence rate of jaw sarcomas in a given population. The reports mentioned above are based upon materials obtained in different hospitals and do not reflect the true incidence in the population.

Estimation of the incidence rate of a certain malignant tumor in a population is possible only if all cases of malignant disease are registered. Such a registration is now carried out in some countries. The results presented in this article with regard to the incidence rate of jaw sarcomas are based upon the files of the Danish Cancer Registry.

In 1942 the Danish National Anti-Cancer League opened a National Cancer Registry with the support of the National Health Service and the Danish Medical Association. The principal task of the registry as lined out by its director, Johannes Clemmesen,[2] is to collect material which might serve as a basis for (1) reliable morbidity statistics, (2) an accurate estimate of differences in incidence of cancerous diseases at various times and in various areas and occupations, and (3) statistics on individual persons for use by physicians as well as for the study of multiple cancers and coincidence with other diseases.

In Denmark it is quite safe to assume that no patient will be cured of a malignant disease without visiting a hospital. Therefore, the registry is considered efficient when all hospital services report cases of malignant disease and when such notifications are later supplemented by death certificates provided through the courtesy of the National Health Service.

As malignant diseases are grouped all cases of carcinoma, sarcoma, and all intracranial and bladder tumors, whether regarded as malignant or not, and

From the Danish Cancer Registry (Director: J. Clemmesen, M.D.) and the Dental Department, University Hospital, Copenhagen.

This study was supported by a grant from the Danish State Research Foundation.

all cases of leukemia, myelomatosis, lymphogranulomatosis (Hodgkin's disease), and mycosis fungoides.

Cards are filed according to date of the patient's birth, and an accessory alphabetical file is also kept.

Numerous papers based on the material collected in the registry have already appeared.[4] In 1956 an account of the cancer incidence in Denmark from 1943 to 1953 was published by Clemmesen and Nielsen.[3] The total number of malignant diseases recorded for that period was 112,112. This means an average of 10,192 new malignancies per year in a country whose population was 3.95 million in 1943 and 4.37 million in 1953. The figures for the buccal cavity and pharynx are given in Table I.

TABLE I. INCIDENCE RATES FOR TUMORS IN THE BUCCAL CAVITY AND PHARYNX IN DENMARK, 1943 TO 1953, ACCORDING TO CLEMMESEN AND NIELSEN[3]

	MALIGNANT DISEASES		PERCENTAGE OF ALL MALIGNANT NEOPLASMS		AVERAGE NUMBER OF MALIGNANT TUMORS PER YEAR	
	WOMEN	MEN	WOMEN	MEN	WOMEN	MEN
Lip	104	1,370	0.17	2.70	9.5	124.5
Tongue	162	165	0.26	0.32	14.7	15
Salivary gland	204	168	0.33	0.33	18.5	15.3
Mouth	143	231	0.23	0.45	13	21
Tonsil (throat)	28	66	0.05	0.13	2.5	6
Pharynx, hypopharynx and unspecified	93	198	0.15	0.39	8.5	18
Lymphosarcoma and reticulosarcoma	63	88	0.10	0.17	5.7	8
Other and unspecified sarcomas	13	27	0.02	0.05	1.2	2.5

All cards for patients with suspected jaw sarcoma were taken out and letters were written to the hospitals for additional information on all clinical data. Radiographs and histologic slides were received by me. In some cases the diagnosis of jaw sarcoma had to be abandoned. The total number of jaw sarcomas found in this way was forty-three.

TABLE II. DISTRIBUTION OF MATERIAL ACCORDING TO AGE AND SEX

AGE GROUP	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
Number of sarcomas	1	4	7	4	9	4	7	6	1

Number of men	26
Number of women	17
Total	43

Six cases of systemic disease of a sarcomatous nature were included in the forty-three cases because the first symptom happened to be in the jaws. Table II shows the distribution according to age and sex. It should be noted that the men:women ratio is 1.5:1. The maxilla was the seat of the sarcoma in twenty-eight cases, and the mandible in fifteen cases. Table III shows the distribution according to histologic diagnosis and is arranged in order of falling frequency.

In Table IV the histologic types are grouped according to location. It is interesting to note that the reticulosarcoma occurs predominantly in the maxilla.

TABLE III. DISTRIBUTION OF FORTY-THREE CASES OF JAW SARCOMA ACCORDING TO HISTOLOGIC DIAGNOSIS

HISTOLOGIC DIAGNOSIS	NUMBER OF CASES
Reticulosarcoma	11
Osteolytic sarcoma	8
Fibrosarcoma	8
Osteosarcoma	7
Lymphosarcomatosis, reticulosarcomatosis, multiple myeloma	6
Chondrosarcoma	1
Ewing's sarcoma	1
Malignant osteoclastoma	1
Total	43

Assuming a frequency of four jaw sarcomas per year (forty-three cases in eleven years) and a population of about 4 million, it could be crudely estimated that in one year one should expect to find one case of jaw sarcoma per 1 million persons in a population whose age distribution and living conditions are similar to those found in Denmark.

TABLE IV. DISTRIBUTION OF HISTOLOGIC TYPES ACCORDING TO LOCATION

HISTOLOGIC DIAGNOSIS	LOCATION	
	MAXILLA	MANDIBLE
Reticulosarcoma	10	1
Osteolytic sarcoma	6	2
Fibrosarcoma	4	4
Osteosarcoma	2	5
Lymphosarcomatosis, reticulosarcomatosis, multiple myeloma	4	2
Chondrosarcoma		1
Ewing's sarcoma	1	
Malignant osteoclastoma	1	
Total	28 cases	15 cases

SUMMARY

The incidence rates for malignant diseases in the buccal cavity and pharynx in Denmark from 1943 to 1953 are reported. Forty-three cases of jaw sarcoma are analyzed according to sex, age, location, and histologic types. It is estimated that in one year one should expect to find one case of jaw sarcoma per 1 million persons in a population similar in age distribution and living conditions to that found in Denmark.

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EXODONTIA

EFFECT OF LOCAL APPLICATION OF TRYPSIN ON POSTEXTRACTION ALVEOLAR OSTEITIS

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INTRODUCTION

IT IS generally accepted that healing conditions in the oral cavity are very favorable. Extractions are seldom followed by infection of the traumatized tissue, despite contamination with the rich oral microbial flora and in spite of the fact that the wound often heals by secondary intention which otherwise increases the risk of complications. That osteitis nevertheless does occur occasionally is hardly astonishing. Despite many investigations, the cause of such osteitis is not properly understood.[9, 19] With our present knowledge, therefore, it is not possible to prevent or appreciably shorten the duration of postextraction alveolar osteitis by any causal therapy. Neither can the pain be controlled satisfactorily by analgesics.

Postoperative osteitis is generally known under the misleading name of "dry socket." The alveolus is not dry; it is empty or contains a necrotic blood clot. The condition is sometimes referred to as alveolitis dolorosa, since pain is regarded as being just as regular a feature as defectiveness or absence of the blood clot. Postextraction alveolar osteitis is a more adequate name, from a pathologic-anatomic point of view, and is therefore used in this article.

Postextraction alveolar osteitis is relatively rare. Krogh[18] found that the condition occurred in 138 alveoli (2.16 per cent) following extraction of a total of 6,403 teeth (4,403 simple and 2,000 surgical extractions). Archer[2] reported a frequency of about 1 per cent following 24,575 tooth extractions. On the basis of 100 cases of the condition Lehner[21] reported a frequency of 2 to 3 per cent. He pointed out that none of the patients was below 18 years of age. That postextraction alveolar osteitis is extremely rare in children was confirmed by a study of the files of the department of pedodontics of The Royal Dental School in Malmö. From 1949 to 1957 some 10,000 deciduous teeth had been extracted. Only seven patients (0.7 per cent) returned with symptoms of alveolar osteitis.[25]

From the Department of Oral Surgery, Royal Dental School, Malmö, Sweden (Head: Professor Hilding Björn, M.D.).

Etiology.—Pre-existing infection or infection entering during or after operation, traumatization of the tissues, and removal of the blood clot by excessive rinsing of the mouth were regarded as the causes of postextraction alveolar osteitis. Nowadays the most important factor is believed to be a deficient blood supply.[19] Lehner[21] regarded postextraction alveolar osteitis as a "localized avascular necrosis." The impairment of the blood supply is often due to the teeth being surrounded by massive cortical bone, as in the molar portion of the lower jaw, or to sclerosis of the cancellous bone around the tooth.[18, 21] Some authors are of the opinion that tooth extraction under infiltration analgesia is more frequently followed by alveolar osteitis than extraction under general anesthesia.[2, 19, 21] The transitory ischemia might then be of importance. Bernier[4] has stressed the importance of proteolytic enzymes in the organization of the blood clot: "These proliferating endothelial and fibroblastic cells concomitantly liberate proteolytic enzymes, which dissolve the clot at a rate which parallels the formation of granulation tissue." Synchronization of the destruction of the blood clot and the formation of granulation tissue is believed to be of importance. Both processes require an adequate supply of blood, as well as the necessary clotting factors, to the clot.

Diagnosis.—Diagnosis is based on the presence of excruciating pain for a varying number of days, a fetid odor, and necrosis of the clot or the absence of any clot.

Therapy.—No specific therapy is available. This is apparent from the many therapeutic measures suggested. Various disinfectants (with or without the addition of local anesthetics), caustics, antibiotics, vitamin injections, antihistamines, and physical treatment have been tried and recommended. Surgical revision of the alveolus has been used but without success.[14, 19] It is a common practice to rinse the alveolus with warm physiologic saline solution and then to apply gauze soaked with some eugenol ointment[2, 4, 18, 22] or phenol camphor.[33] A few previous trials have been made with proteolytic enzymes,[24] but these agents were not widely used until recently.

PREVIOUS INVESTIGATIONS OF THE THERAPEUTIC EFFECT OF PROTEOLYTIC ENZYMES

Proteolytic enzymes or substances activating endogenous proteolytic enzymes have been used since the beginning of the twentieth century in the treatment of poorly healing wounds and osteomyelitis. In 1934 Garner and Tillet[11] discovered a fibrinolytic effect of hemolytic streptococci. Later investigations by Sherry and associates[27] showed that certain hemolytic strains of streptococcus produce two different products of significance in proteolysis. They form streptokinase, which activates plasminogen, and streptodornase, which is an active proteolytic enzyme. This enzyme depolymerizes desoxyribose nucleic acid and desoxyribose nucleoprotein in the nuclei of dead cells. A combination of streptokinase and streptodornase, as in Varidase (Lederle), has been used in the treatment of burns, hemothorax, and empyema.[6]

The favorable effect of the invasion of infected wounds by the larvae of flies has been known since ancient times. It is therefore interesting to note that Miller discovered that trypsin is the most important enzyme in the excretion of these larvae.[8] Trypsin hydrolyzes different kinds of proteins but appears to have only a weak effect on native proteins. On the other hand, it has a strong effect on denatured proteins.[13] In addition, trypsin activates the transformation of plasminogen into plasmin with a fibrinolytic effect as a result.[3] Trypsin, which has a molecular weight of 34,000, is a simple globulin without any demonstrable prosthetic group.[28] Its effect is optimal at body temperature and at a pH of 7.8 to 8.7.[12]

Formerly, pancreatic extract was used,[24] but nowadays purified trypsin preparations are the rule. A preparation of this sort is Trypure (Novo Industri A/S, Copenhagen). The preparation is supplied as a dental cone containing 5 mg. of crystalline trypsin and as a dental ointment containing 2 per cent crystalline trypsin in a water-soluble base containing polyethylene glycols. Every cone has a proteolytic activity of 0.125 Anson units corresponding to 31.2 Willstätter units. The activity of the ointment is 1.25 Anson units or 312 Willstätter units per gram.

Trypsin not only removes necrotic debris,[5, 26] but it also exerts a thrombolytic effect by virtue of its fibrinolytic activity.[15, 27] If we accept Bernier's and Kruger's opinion that a deficient local blood supply is the main cause of postextraction alveolar osteitis, treatment with trypsin could be regarded to a certain extent as a causal therapy, provided, of course, that the lack of blood supply to the clot in the alveolus is due to thrombosis of the surrounding vessels.

A study of published reports of the effect of trypsin on postextraction alveolar osteitis revealed only good results.[7, 29, 30] These reports, however, are based on relatively small series which do not include control groups of patients who received no treatment at all or were treated by other methods. Favorable results have also been reported by Anderson[1] and Toto.[31] Anderson applies iodoform gauze after application of the trypsin, and Toto uses a trypsin-antibiotic preparation and eugenol dressing. Similar methods have been used with good results by Garguilo and Staffileno.[10] In none of these investigations, then, was a study made of the effect of trypsin by itself. Conclusions drawn from these investigations can therefore be of only limited value.

PRESENT INVESTIGATION

The purpose of the present investigation was to assess the effect of trypsin on the predominant clinical symptom (pain) of postextraction alveolar osteitis and to demonstrate any undesired side effects of the preparation.

Method.—The trypsin preparation used (Trypure Novo) and placebos were supplied by AB Ferrosan, Malmö, Sweden, in the form of dental cones and an ointment. Patients to be treated with Trypure Novo or a placebo were selected at random. Once the selection had been made, the patient received either Trypure Novo only or the placebo only throughout the investigation. The

examiner did not know whether he was treating his patient with an active preparation or with a placebo, and the patient was not aware of the fact that he was taking part in a clinical trial.

Material.—The material consisted of patients in whom alveolar osteitis had developed after extraction of teeth at the Department of Oral Surgery, Royal Dental School, Malmö. It is not the rule to examine patients routinely after extraction of teeth. Therefore, the patients in the present series had returned because of symptoms. During the year of the investigation, seventy cases of alveolar osteitis (1.2 per cent) were noted following extraction of a total of 5,679 teeth. The ages of the thirty-three male and thirty-seven female patients ranged between 16 and 61 years (mean, 34.5 years). Diagnosis was based on the occurrence of extreme pain, fetid odor, a necrotic clot, or the absence of a clot in the socket.

During the year of the investigation the patients with postextraction alveolar osteitis were treated with Trypure Novo in accordance with the manufacturer's instructions.

The alveolus was rinsed with warm physiologic saline solution, after which a Trypure Novo dental cone or placebo was applied to the alveolus, which was then filled to the brim with Trypure Novo dental ointment or placebo. The patient was instructed not to rinse the mouth for the next three hours. The treatment was repeated every day until the pain had ceased.

Results.—

Duration of pain: The average duration of pain after the start of treatment was 4.2 days in the group treated with Trypure and 4.6 days in the group treated with placebo. The difference (0.4 day) was not statistically significant.

Side effects: Five (13 per cent) of the thirty-eight patients treated with Trypure developed erosions on the tongue, lips, and mucosa of the cheeks. No erosions occurred in the control group. Of the thirty-eight patients treated with Trypure, twenty-eight (74 per cent) complained of a burning sensation following application of the preparation, but none of the patients treated with the placebo made this complaint.

DISCUSSION

The present investigation produced no evidence in support of the view presented by previous workers that proteolytic enzymes have a beneficial effect on postextraction alveolar osteitis. However, the fact that the difference in the mean number of days of pain after initiation of treatment is not statistically significant does not exclude the possibility that it might have been significant if the series had been larger. An important question is, "How large a difference could be expected if two very large groups of patients were treated in the same way as in the present investigation?" On application of a statistical method described by Wilcoxon[34] in 1945, it was found that the mean difference would with 99 per cent certainty be less than two days. A prerequisite, of course, is that the patients examined in the present investigation can be regarded as a

random selection of a supposed very large group of patients. This implies that it may be concluded with fairly satisfactory certainty that treatment with trypsin shortens the duration of pain by two days at most if used on the type of patients studied in the present investigation.

The value of investigations of this type is limited by lack of objectively recordable factors. As in previous investigations,[1, 2, 30] the effect of treatment was judged by the duration of pain as described by the patient, since this was the predominant symptom. In an attempt to graduate the severity of the pain, notes were made as to whether the pain had been so severe as to disturb sleep and whether the effect of ordinary analgesics had been considered satisfactory.

The discrepancy between the results obtained in the present investigation and those described by earlier investigators concerning the effect of trypsin may be due to the fact that the present material included a control group of patients who received a placebo. This prevented any difference between the two groups because of the psychologic effect of the treatment per se. That treatment can have a favorable effect due to suggestion has been shown by Keesling and Keats[17] in an investigation of the effect of a placebo compared with that of various oral analgesics in the treatment of postextraction alveolar osteitis. They thus noted placebo had a good effect on the pain in 61 per cent of sixty-seven patients treated. Other workers in this field[16, 20] have recently arrived at similar conclusions.

In the present investigation the mean duration of the pain of postextraction alveolar osteitis was 7.2 to 8.2 days after extraction of the tooth. This figure does not differ appreciably from that given by earlier authors (Krogh, ten days; Waite, ten to fourteen days; Mead, two to three weeks). The mean duration of 7.2 to 8.2 days, is somewhat shorter, however, which might imply that both the Trypure and the placebo shortened the duration of pain and in this respect had equally good effects, or the effect may be ascribed to the rinsing with physiologic saline solution before application of the preparation. The variation in the duration of the pain of postextraction alveolar osteitis was considerable, however, among individual patients. No exact data on this point can be obtained from the literature. Since the duration of pain varied from two to eighteen days after rinsing with physiologic saline solution and application of the placebo, it is not possible to predict how long a given patient will suffer from pain if the condition is left untreated. Therefore, it is difficult to demonstrate any appreciable shortening of the duration of pain by treatment. This fact must be borne in mind in the evaluation of the results of treatment. This and the considerable effect of placebo in blind tests on record imply that one must question whether investigations of results of treatment of alveolar osteitis with trypsin permit a real evaluation of the drug.

In three of the patients it was necessary to terminate treatment because of side effects which occurred in the form of erosions in association with severe subjective symptoms. Of the twenty-eight patients who complained of a burning sensation after treatment, four had such severe pain that treatment had to be abandoned. It was therefore necessary to give up treatment with Trypure in a total of seven cases.

Because of the fibrinolytic effect of trypsin, one might expect an increased bleeding tendency in the Trypure-treated group. No such tendency was observed.

Since the difference found between the duration of pain in the two groups was too short to be of any practical importance, it is not worth our while to try to ascertain what factors might be responsible for this small difference. Neither does there appear to be any reason to reinvestigate the problem on a larger scale, particularly as treatment with the enzyme often had undesirable side effects.

SUMMARY

Local application of the proteolytic enzyme trypsin (Trypure Novo) was studied for any beneficial effect on the symptoms (particularly pain) of postextraction alveolar osteitis. The trial was performed as a blind test. Of a total of seventy patients, thirty-eight selected at random were treated with trypsin and the remaining thirty-two served as controls and received a placebo.

The duration of pain was not significantly shorter in the patients treated with trypsin than in those who received a placebo. Furthermore, in about 70 per cent of those who received trypsin the preparation produced a sensation of burning, and in 15 per cent it caused superficial erosions at the site of application.

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PERIODONTICS

MORPHOLOGY OF INTERDENTAL GINGIVAL TISSUES

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IN THE various textbooks of dental histology and periodontology,[1-5] the gingival tissue between two adjacent teeth is called "interdental or gingival papilla." Sorrin[1] states: "This zone is roughly pyramidal or triangular in shape." Orban and associates[5] also say: " . . . the interdental papillae are roughly pyramidal in shape." According to Goldman and his colleagues[6] a cone-shaped or pyramidal form is necessary if these tissues are to perform the function of interproximal deflection of food debris.

Recently, Cohen[7, 8] has disagreed with this description of the morphology of the interdental tissue. He has found, in his study of human and monkey material, that the interdental gingiva consists of a buccal and a lingual peak; between the peaks is a depression similar to the shape of a mountain col. Moreover, after studying this area on serial buccolingual sections of monkey jaws with mixed dentitions, he feels that "the col surface is derived from the juxtaposition of reduced enamel epithelia covering adjacent teeth, the oral mucosa between the teeth having separated into the lingual and labial (or buccal) papillae except in those instances where a diastema is present."[8]

We therefore decided to conduct an experiment on young adult rhesus monkeys to see (1) whether the textbooks' or Cohen's description is correct, (2) whether surgical removal of interdental tissue would result in an alteration of its morphology, and (3) whether the appearance of the epithelium covering the col (Cohen) or the tip of the "papilla" is different in permanent and deciduous dentitions from that described by Cohen in the mixed dentition.

MATERIAL AND METHODS

A young rhesus monkey with a complete deciduous dentition and two young adult monkeys with complete permanent dentitions (except for the third molars, which had not yet erupted) comprised the material for this study.

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The two adult monkeys were anesthetized by intravenous injections of Nembutal sodium. In one monkey, all interdental soft tissue on the right side (upper and lower jaws) was surgically removed as far as the underlying bony septum. In the other, all such gingival tissue on the left side was removed. In each case the opposite side was left untouched.

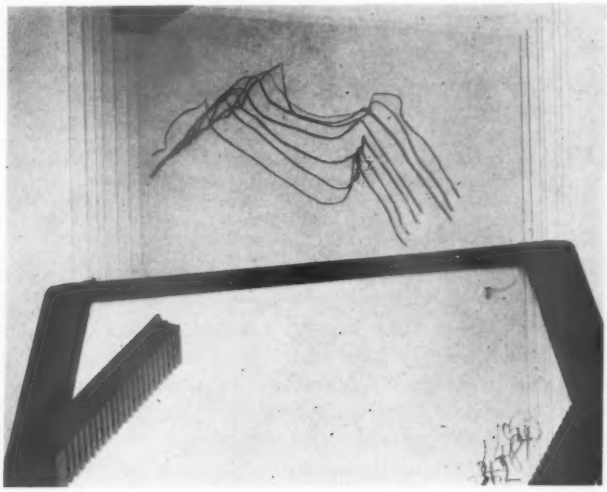


Fig. 1.—Drawings from seven buccolingual sections of interdental gingival tissue juxtaposed on a rack. These drawings, while serially arranged, are placed farther apart than the actual scale, thus giving a drawn-out view of the mesiodistal dimension. The drawings were made from the original sections, at a magnification of ×15, on 8 by 8 inch Plexiglas sheets.

After two months, a gentle cleaning of the teeth and gingivae was performed with curettes, dental floss, and rubber cups. Clinically, the gingival tissues appeared healthy. Two days later, the monkeys were killed. The jaws were removed immediately, washed carefully, and fixed in 10 per cent neutral formalin for forty-eight hours. Each jaw was then divided into three pieces and decalcified in 5 per cent nitric acid at 30 pounds of pressure per square inch.[9] The jaws were then cut into smaller pieces in such a way that each block was composed of the distal half of one tooth, the interdental tissue, and the mesial half of the adjacent tooth. The specimens were prepared for celloidin embedding and cut serially at 12 microns. Sections were cut buccolingually as nearly perpendicular as possible to the mesiodistal plane. A few blocks, however, were cut in the mesiodistal plane. The sections were stained with hematoxylin and eosin.

Drawings of the outline of the interdental gingiva were made as follows: Each buccolingual section was projected on a sheet of Plexiglas at a magnification of ×15. The contour of the soft tissue was drawn on the sheet. As very little change appeared between adjacent sections, each preceding one was taken as a reference to orient the following one. Drawings, from the first section which no longer showed a piece of tooth to the last one before the

appearance of the next tooth, were arranged serially. To avoid too many crossing lines and to give a drawn-out view of the mesiodistal dimension, the drawings of only every third section were juxtaposed on a rack at 1 cm. intervals (Fig. 1). Artist's drawings of the interdental gingiva were also made from this assemblage (Figs. 2 and 3).

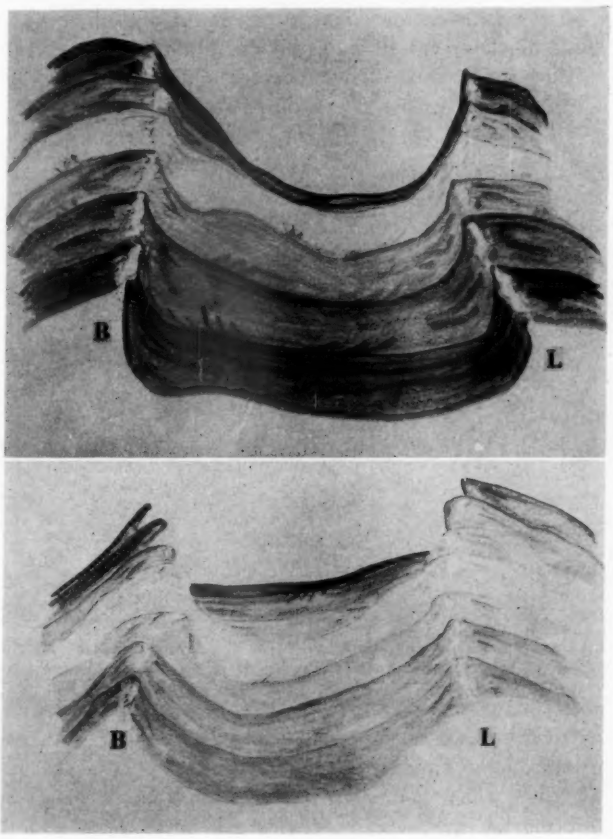


Fig. 2.—*A*, Artist's drawing from seven sections on a rack, as shown in Fig. 1. This represents the interdental gingiva between the first and second upper right molars on the control side. *L*, Lingual; *B*, buccal.

B, Drawings of the corresponding interdental gingiva on the operated side (upper left). *L*, Lingual; *B*, buccal.

In addition to being observed for the shape of the interdental gingiva, the stained sections were also used to study the structure of the epithelium.

Besides the monkey material, we obtained two autopsy specimens from a 60-year-old man. The first one consisted of contacting first and second lower left premolars with their surrounding soft tissues; the second consisted of the lower left lateral incisor and cuspid. No restorations or dental caries

were present. The amount of occlusal wear and the depth of the gingival crevice were thought to be within the range of normal for the age of the person. The specimens were fixed and treated in the same way as the monkey material.

RESULTS

Outline of the Interdental Gingiva.—Examination of the sections from the young adult monkeys cut in a mesiodistal plane always revealed a single sharp peak. However, examination of the serial sections cut perpendicularly

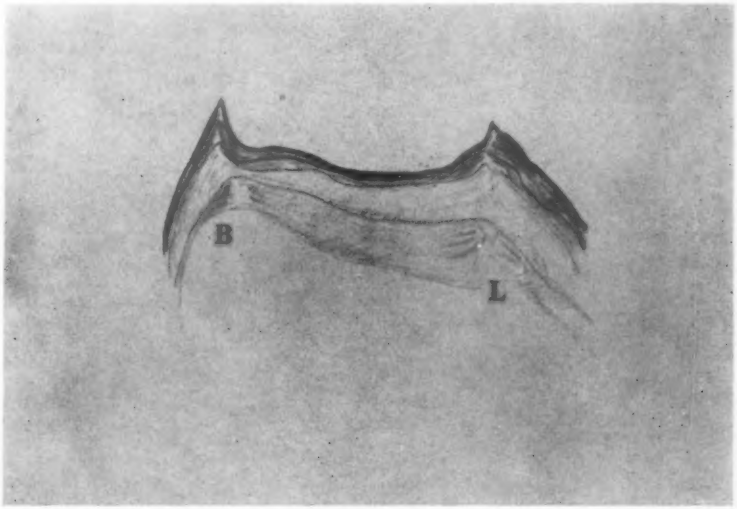


Fig. 3.—Drawing of interdental gingiva between the upper right central and lateral incisors. *L*, Lingual; *B*, buccal.

to a mesiodistal plane revealed a depression between a buccal and a lingual peak. When drawings were made and assembled to give a three-dimensional view of the interdental gingiva, the buccal and lingual peaks appeared connected by a "col" which had mesial and distal slopes. This shape was the same on both the operated and control areas (Fig. 2, *A* and *B*). In the molar areas the col was deeper and the peaks were farther away from each other than in the anterior area (Fig. 3). In the premolar areas the morphology of the interdental gingiva resembled that of the molar areas, except that the buccal and lingual peaks were not as far apart from each other.

The interdental gingiva from the monkey with the primary dentition showed a similar col shape whenever adjoining teeth were in contact; when a diastema was present, as in the anterior region, a cone shape appeared.

In the two human specimens, as well as in the monkey material, the col shape with its mesial and distal slopes and the two peaks could already be

seen grossly after decalcification had removed the enamel and thus opened the interdental area to view (Fig. 4).

Epithelial Covering of the Interdental Gingiva.—

The buccal and lingual peaks: The peaks were covered with a thick keratinized epithelium. There was little sign of inflammation in either peak area (Fig. 5).

The "col" area: In the col we found squamous stratified nonkeratinized epithelium, the thickness of which was much less than that over the peaks. Usually it was about four cell layers deep. Epithelial extensions into the connective tissue were more irregular than those into the peak epithelium.

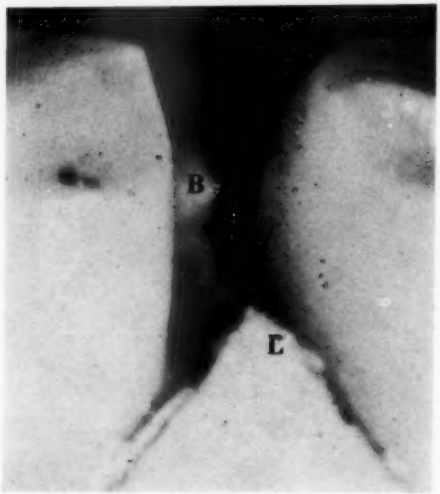


Fig. 4.—Photograph of an interdental area between lower left first and second premolars. Decalcified human autopsy specimen. Through loss of the enamel, the shape of the interdental gingiva can be seen. *L*, Lingual peak; *B*, buccal peak. A col with mesial and distal slopes appears between the two peaks.

They were narrower and deeper. There were always signs of inflammation in the connective tissue, and this inflammation was more pronounced in the section equidistant from the two adjacent tooth surfaces (Fig. 6). Infiltration of inflammatory cells throughout the epithelium, or even ulceration, could be seen in this section. Where ulceration was present, the epithelial extensions seemed to form a bridge well within the connective tissue. The inflammation was not seen to extend further than the transverse fibers of the attached gingiva and the most superficial part of the fibers of the periodontal membrane.

Moving away from the midsection toward the tooth, we came to the mesial or distal slope of the col. On these slopes the epithelial extensions became less numerous until in the section closest to the tooth surface the epithelium took on the characteristic appearance of the epithelial cuff (epithelial attachment) (Fig. 7). The inflammation also decreased until there was hardly

any in the last section of the slope. The epithelium on the operated side, where the interdental gingiva was only 2 months old, appeared identical with that on the control side (Figs. 8 and 9). On both the operated and the control sides the epithelial cuff cells did not extend apically from the cementoenamel junction.

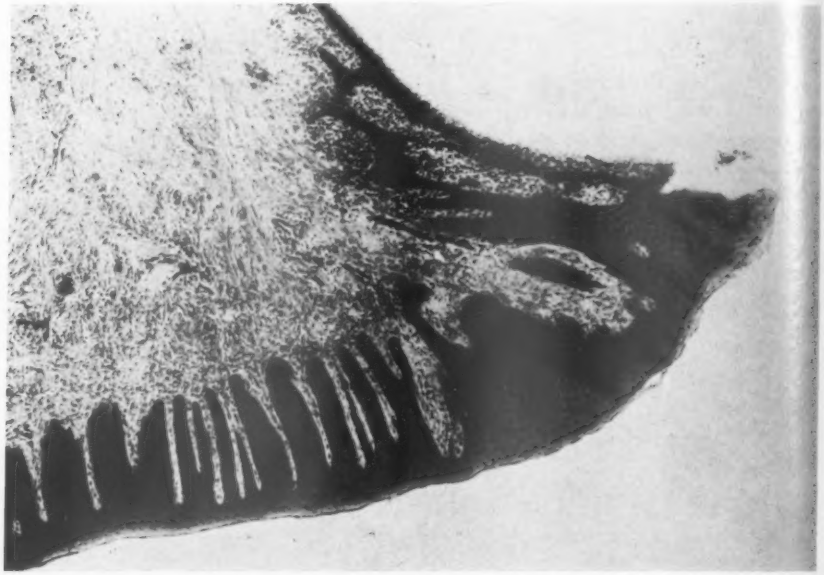


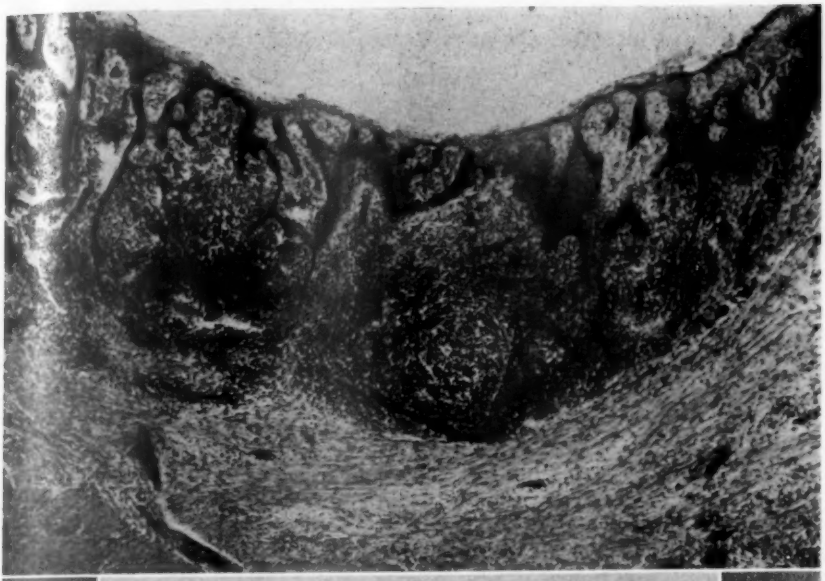
Fig. 5.—Photomicrograph from buccolingual section of the labial peak of interdental gingiva (control side). (Hematoxylin and eosin stain. Magnification, ×78; reduced ¼.)

INTERPRETATION OF RESULTS

Our findings confirm Cohen's observations on the shape of the interdental gingiva. Even though we could obtain only two human specimens for sectioning, we agree with Cohen[8] and with Baume and Becks[10] that the dentition of the rhesus monkey resembles that of man. Moreover, during extraction of teeth in man, we have been able to observe in the human mouth cols and peaks as described in this article. We have also observed them in biopsy sections from healthy human interdental gingiva. Therefore, we feel that the textbook description of the interdental gingival tissue as "pyramidal or triangular papilla" is no longer warranted. Such a description is derived from superficial examination of mesiodistal sections only. When viewed three-dimensionally in buccolingual as well as in mesiodistal sections, the interdental gingiva appears to have buccal and lingual peaks with a col in between. This is the correct description of the shape of the interdental gingiva.

Our experiment also shows that the interdental gingiva reshapes itself with the same outline within two months after surgical removal. This means that the attainment of the textbook picture of a pyramidal or triangular

Fig. 6.



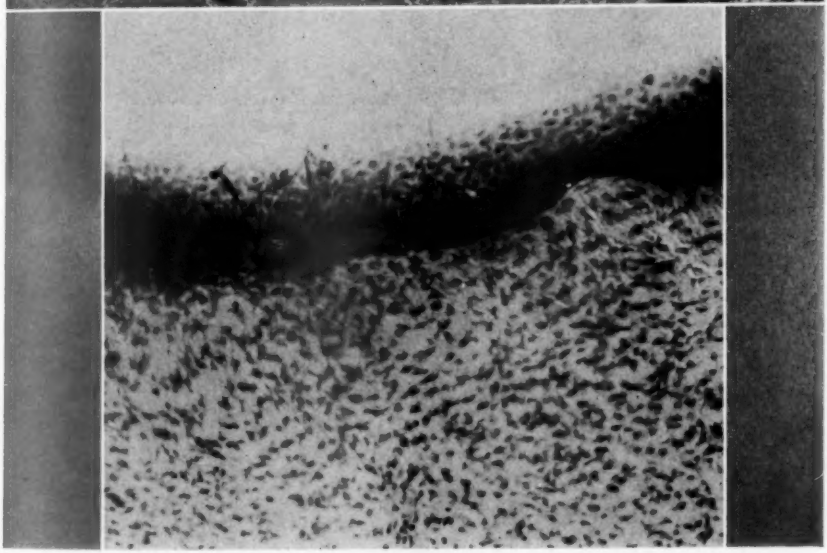


Fig. 7.

Fig. 6.—Col area of interdental gingiva. Photomicrograph of buccolingual section equidistant from the two adjacent tooth surfaces (control side). Note thinness of epithelium, irregular deep epithelial extensions, and severe inflammation. (Hematoxylin and eosin stain. Magnification, ×78; reduced ¼.)

Fig. 7.—Photomicrograph of buccolingual section of the interdental gingiva close to the tooth surface, showing characteristic appearance of the epithelial cuff (control side). (Hematoxylin and eosin stain. Magnification, ×244; reduced ¼.)

interdental papilla by means of gingivoplasty seems doomed to failure. It may be better to reshape the anatomy of the adjoining tooth surfaces in some manner if a pyramidal shape of the interdental gingiva is desirable. Such

Fig. 8.

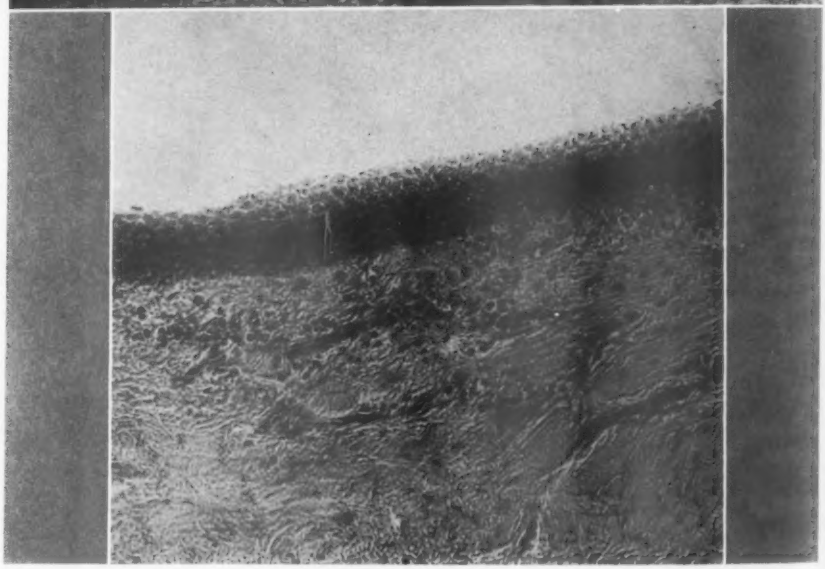


Fig. 9.

Fig. 8.—Photomicrograph of same area as Fig. 6, but on operated side.
Fig. 9.—Photomicrograph of same area as Fig. 7, but on operated side.

experiments with different artificially created tooth shapes are under way. Moreover, our finding of varying sizes of the col in different areas of the mouth is already an indication of the influence of tooth morphology upon the shape of the interdental gingiva.

The appearance of thin, nonkeratinized epithelium on the col on both the operated and the control sides indicates to us that the buccal and lingual oral mucosa grows over to form the new col without a thick, keratinized layer. In order to get, on the col, a keratinized stratified epithelium like that on the peaks, the interdental gingiva must be exposed to the mechanical stimulation of food and toothbrush. This can be accomplished only by changing the anatomy of the interdental area. As previously shown by Waerhaug and Zander[11-13] the relationship of the epithelium to the tooth surface seems to determine the morphology of the epithelium.

CONCLUSIONS

1. Our findings confirm Cohen's description of the morphology of the interdental gingiva. This tissue consists of a buccal and a lingual peak (papilla) connected by a "col" which has mesial and distal slopes. The shape of this col varies in the different interdental areas.

2. If the interdental gingival tissue is removed on one side of the jaw, within two months it will take on the same shape as the unoperated or control side. The shape of the interdental gingiva appears to be related to the morphology of the interdental space created by its adjacent tooth surfaces.

3. The epithelium covering the col area, in contrast to that over the peaks, is thin and nonkeratinized, and there is a great deal of inflammation beneath it.

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ORAL MEDICINE

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METHOCARBAMOL IN THE TREATMENT OF TEMPOROMANDIBULAR JOINT SYNDROME

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SYMPTOMS involving pain about the face and neck, trismus, popping or crackling sounds when the jaw is moved, etc. are usually indicative of Costen's syndrome, more properly called temporomandibular joint syndrome. Although the temporomandibular joint syndrome is not encountered often, it occurs with enough frequency and presents enough difficulties with regard to diagnosis and management that it is a significant problem in the field of dentistry. The etiology of the syndrome varies from patient to patient, depending upon predisposing factors. Malocclusion, various forms of arthritis, trauma, strain of the joint, fracture of the ramus or body of the mandible, muscle spasm, and numerous other conditions have been incriminated as the underlying causes.

Meniscitis is also commonly associated with the temporomandibular joint syndrome. The pain and snapping that occur when the mouth is opened or closed are often due to fixation of the meniscus by spasm of the superior portion of the pterygoid muscle.[1] This blocking or displacement of the meniscus prevents the patient from opening or closing his mouth completely. Intracapsular and interarticular derangements may reflexively cause contraction of the superior fibers of the external pterygoid and tend to move the meniscus forward.

Dental practitioners who treat this syndrome often make occlusal corrections and construct new replacements to re-establish the mechanism of occlusion. Although many patients find immediate relief from such treatment, the treatment itself may be unphysiologic. These procedures may merely cushion the condyle in a position that is more comfortable without correcting the underlying pathology. A different approach is to place the patient on a treatment program aimed at relieving the spasm of the masticatory muscles and reducing inflammation of the joint.

A preliminary study of the effect of a skeletal muscle relaxant, methocarbamol,* on patients with symptoms of temporomandibular joint syndrome is reported here.

*Supplied as Robaxin, a product of A. H. Robins Company, Inc., Richmond, Virginia.

PLAN OF STUDY

Thirteen patients with symptoms of temporomandibular joint syndrome were seen in an oral surgery practice. In this group there were eleven women ranging in age from 18 years to 56 years, a 13-year-old boy, and a 45-year-old man (Table I). All had normal occlusions, except for three who had rather severe overjets. Dentition ranged from normal in three patients to full

TABLE I. CASES TREATED WITH METHOCARBAMOL FOR RELIEF OF TEMPOROMANDIBULAR JOINT SYNDROME

CASE	AGE	SEX	DURATION OF SYMPTOMS	PRIOR SYMPTOMS	DENTITION	OCCLUSION	METHOCARBAMOL (500 MG. TABLETS)	RESULTS	RECURRENCE
1	45	M	6 days	Yes	Normal	Normal	2 t.i.d.	Good	None
2	13	M	2 days	No	Third molars unerupted	Normal	2 t.i.d.	Good in 3 days	None
3	19	F	3 months	No	Impacted third molar	Extreme overjet	1 t.i.d.	Good in 2 days	None
4	29	F	1 month	Yes	Third molar removed	Normal	2 t.i.d.	Good in 4 days	None
5	56	F	9 months	Yes	Full dentures	Decided overjet	2 t.i.d.	Good in 4 days	None
6	33	F	2 months	No	Mandibular posterior and maxillary anterior teeth missing	Extreme overjet	1 t.i.d.	Good in 3 days	None
7	24	F	—	Yes	Full dentures	Normal	1 t.i.d.	Good	None
8	48	F	2 days	No	Normal	Normal	2 q.i.d.	Good	None
9	53	F	1 day	No	Lower third molar missing	Normal	2 t.i.d.	Good	None
10	18	F	2 weeks	No	Normal	Normal	2 q. 4 h.	Fair in 1 day, good in 1 week	None
11	38	F	2 months	No	Third molar removed	Normal	2 q. 4 h.	Good in 1 week	None
12	43	F	17 years	No	Third molar removed	Normal	2 q. 4 h.	Poor	—
13	52	F	2 years	No	Third molar removed	Normal	2 q. 4 h.	Good	1 recurrence which responded to treatment

artificial dentures in two. From the clinical standpoint, a large percentage of the patients tended to be tense and anxious. When first seen eight of the patients reported that their symptoms were of recent origin; in the other five patients, the symptoms were of more than one month's duration.

The patients were treated with a regimen of external heat; rest; high-protein, soft, nonchewy diet; vitamin supplements; and methocarbamol. Methocarbamol, 3 to 8 grams daily, was administered in divided doses.

The evaluation of response was based on subjective and objective findings. A good response was recorded when there was complete alleviation of subjective symptoms and of such objective symptoms as preauricular tenderness and inability to masticate or attain a centric occlusion without pain. There was one "poor" response in which the patient received only minimal relief of pain and spasm. In no case did the treatment fail completely. Care was taken to exclude patients with symptoms arising from such conditions as impacted third molars, maxillary sinusitis, middle ear infection, and tic douloureux. It is easy to differentiate between these conditions and the temporomandibular joint syndrome if the clinician takes a careful history and performs an adequate physical examination.

RESULTS

Good results were obtained in twelve of the thirteen cases treated with methocarbamol in this series. The only patient who did not respond to the treatment (Case 12) had suffered from temporomandibular joint syndrome for seventeen years. There was only one recurrence, and this patient (Case 13) responded well to retreatment. There were no apparent side effects, with the exception of one case of hypotension in a patient known to have poor drug tolerance.

DISCUSSION

The symptom complex described by Costen[4] in 1934 included such disturbances as pain in the temporomandibular joint region, intermittent or continuously impaired hearing, stopping or "stuffy" sensation in the ears (marked about mealtimes), tinnitus (usually a "low buzz" in type, less often a snapping noise while chewing), dull or "drawing" pain within the ears, and dizziness with nystagmus. Since then Costen has reported other findings, most of which have become a part of the syndrome. Costen attributed the symptoms to overacting closure of the mandible due to erosion of the bone of the glenoid cavity and pressure of the condyle on the worn or perforated meniscus.

There is considerable disagreement, however, as to whether the syndrome, as such, actually exists. In a series of 491 cases treated in the Temporomandibular Joint Clinic at Columbia University, Schwartz and associates[2] reported that the syndrome described by Costen was not found. Currently it is felt by some[3] that the decrease of vertical dimension is in reality a minor factor in the production of joint symptoms and that symptoms are due more to spasm and muscle tension.

Symptoms of the condition usually appear first in the form of a functional incoordination of the masticatory muscles. These symptoms are followed in many cases by spasm of the masticatory muscles characterized by pain and limitation of mandibular movement. In the third stage, which sometimes follows, there is a painless splinting or an accommodative "favoring" of the muscles around the affected joint.

The main pathologic feature of this complex is one of neuromuscular dysfunction similar to that which causes pain in other joints of the body. Joint neuromuscular action is initiated through the nerves of the periodontium. Stimuli from deep proprioceptor fibers of the masticating muscles, the gingivae, and other sensory fibers are referred to the temporomandibular joint. The symptoms can also be initiated through the sensory reflex mechanism in afunctional masticatory movements. This reflex "trips" the meniscus through action of the pterygoid externus muscle and causes the subsequent syndrome.[1] In fact, many patients with this syndrome seem to be tense, nervous persons who tend to hold their jaws locked together during periods of emotional stress.

The symptoms can be relieved by breaking the cycle of tension-spasm-pain-tension which can eventually lead to tonic spasm of the masticatory muscles. Since most cases are in the first and second stages when seen by the dentist or physician, the initiation of a conservative regimen supported by a muscle relaxant to reduce spasm in the muscles around the joint is both rational and physiologically sound.

SUMMARY

1. A conservative regimen consisting of external heat; rest; high-protein, soft, nonchewy diet; vitamin supplements; and methocarbamol (Robaxin) is advanced for the treatment of temporomandibular joint syndrome.

2. The clinical results obtained from this regimen were good in all but one of thirteen cases. The use of oral methocarbamol to relax the musculature around the temporomandibular joint relieves the underlying pathologic condition and enhances the therapeutic effect of the conservative regimen.

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ORAL ROENTGENOLOGY

American Academy of Oral Roentgenology

Arthur H. Wuehrmann, Editor

CURRENT STATUS OF THE UNDERGRADUATE CURRICULUM IN DENTAL RADIOLOGY

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IT WAS only a few years after the discovery of x-radiation that Kells applied what was then known about the behavior of this new x-radiation to the field of dentistry. Like many discoveries, this mysterious new form of energy was ridiculed and played upon by charlatans, but it finally survived to become one of the most helpful diagnostic aids in the fields of dentistry and medicine. Teaching of this new science soon after the turn of the century was almost entirely on the apprenticeship basis. The literature is practically devoid of any reference to the teaching of oral roentgenology in dental schools prior to World War II. Prior to 1930 many dentists graduated without having had access to undergraduate courses in the use of the x-ray unit as a diagnostic instrument. In order to use this new piece of equipment in their offices, it was necessary for dentists either to return to school for refresher courses or to learn from some other practicing dentist. Unfortunately, other dentists' knowledge concerning the use of this equipment was limited, and very few dental schools offered such courses. It was often quite customary and necessary for a salesman, in order to sell a dental x-ray unit, to instruct the dentist in the use of the equipment. The status of the teaching under such circumstances was poor; perhaps it would be appropriate to say it had no real

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Editor's Note: A Workshop on the Teaching of Radiology in Dentistry, which was held at the College of Dentistry, University of Illinois in Chicago, Illinois, on March 18 and 19, 1960, provided information which should be of interest to the readers of this JOURNAL. The papers read at the Workshop, which will be published serially starting with this issue, deal with the present undergraduate curriculum in dental radiology, the future undergraduate curriculum, the status of and available opportunities for advanced education in radiology, and research potentials in this field.

status. It was not until the period just before and after World War II that an increasing number of the dental schools began to offer short postgraduate or refresher courses in the use of x-radiation.

Most dental schools had started to teach the science of dental radiology by the late 1920's or the early 1930's. It was a much narrower field than it is today, and perhaps can more accurately be described as dental roentgenology; the course content was often extremely limited. The science did not gain departmental status in many schools until recent years, and there are, in fact, several schools at present which do not give oral radiology that degree of recognition.

Until recently, practically no teachers of dental radiology were specially trained in their field. Most of them "trained themselves." These early pioneers displayed remarkable initiative and skill in mastering the science. They deserve much of the credit for the prestige which the teaching of dental radiology currently enjoys. Even today, very few teachers have had any formal training in radiology beyond that which was received during their undergraduate education.

Some idea of the status of radiology teaching may be gained from the fact that the American Association of Dental Schools did not establish a Section on Roentgenology until 1955. It was at the thirty-second annual meeting of that Association that the first roentgenology conference session was held. Prior to that, as in 1947, roentgenology had been assigned to one of the afternoon groups for discussion, but the section itself had not been established. The first conference session had as its theme "Correlation of Oral Roentgenography With the Pre-Clinical Sciences."

It will be noted that the terms *roentgenology* and *radiology* are used in a seemingly interchangeable manner throughout this article. One should make an effort to use the term which most accurately describes the activities or scope of the process, technique, or department. *Radiology* is the broader term and is concerned with the study and use of other than just x-radiation. *Roentgenology* implies the study and use of radiation within only a very narrow spectral range. Each school, potentially, has the opportunity of presenting a course or courses in radiology, but actually the product may be only courses in roentgenology. As the scope of activities broadens, as it is now doing, more and more departments, in name and/or in fact, will be departments of radiology rather than of roentgenology.

Some schools do not give departmental status to the teaching of dental radiology. Like other areas in education, departmental lines are drawn according to the personality, training, abilities, and desires of the faculty members involved. No doubt in most instances this is as it should be; a rigidly regimented system is not conducive to progress. Conversely, however, no area of dentistry is more interrelated with other disciplines than is dental radiology. Practically every clinical subject in the dental curriculum depends on radiology to contribute to its diagnostic procedure. Therefore, it seems reasonable that radiology should enjoy departmental recognition. If radiology is to be relegated to a service function, it might be best not to bother with

a teaching staff but to hire technicians for the purpose of exposing and processing the films. Today, most administrators and faculty members agree that service per se is not the prime purpose of this discipline.

Unfortunately, radiology in several schools continues to be a service department, just as diagnosis is occasionally only a patient-screening and patient-routing department. This is not desirable. Departmental status for radiology is essential, especially in those institutions where the work load and teaching load are heavy and where interested, dedicated, and trained teachers are available. This implies that the teacher must be more than a technician. He must have sufficient knowledge of anatomy, surgical pathology, embryology and histology, oral pathology, and oral medicine to enable him to teach effectively the interpretative phases. In medical radiology, it is the exception rather than the rule when the physician actually makes the projections. Dentists probably will continue for many years to make their own x-ray projections, but added emphasis must be given to the proper interpretation of films in the undergraduate curriculum. The technical aspects need be considered only for the purpose of producing film suitable for interpretation. After that, unless all of the film shadows are correctly interpreted, little has been gained. If the technical aspects of radiology are thought of as a *means* and the interpretive phases as the *end*, it becomes both logical and essential to give radiology department status.

It has been said that the past century in dentistry has been highlighted by the development and perfection of restorative techniques. Certainly, these have been developed to a high degree. It has also been postulated that the next century will see emphasis placed upon prevention and control of disease as the technical advances of the first century continue to be employed. Should these developments eventuate, and it certainly appears that they will, dentistry, in further perfecting the technical phases of radiology, will be required to advance its interpretive abilities through research. Even at present our technical advances often provide us with films containing much more information than we are able to interpret. One sees only what one knows. In the future, more emphasis will be placed on the appearances of the normal tissues and their roentgenographic variation and upon the study of the diseases and disease processes and their resultant effects on the dental structures. This means that correlation with anatomy, histology, and pathology as well as with clinical medicine will, of necessity, increase.

The "everyday problems" in dental practice are constantly becoming more and more complex. An example of this is found in periodontics. Here encouraging efforts are being made in the treatment of intra-alveolar pockets, in recontouring the alveolar crest, and in stimulating the regrowth of bone in intra-alveolar pockets. The interpretation of carious lesions offers another example. The use of higher peak kilovoltage, different concepts of radiation absorption and penetration, and films with different emulsion characteristics and contrast contribute to the production of many shades of gray. Through these techniques, minimal tissue changes can be observed; these should challenge the imagination and abilities of the student and his teachers.

It is not within the scope of this article to discuss the various aspects and merits of state board examinations in dentistry. It is noted, however, that all students are required to pass state board examinations before they are licensed to practice. Either directly or indirectly, the curriculum of most dental schools is influenced by the type of examinations offered by state boards. As state boards expand their examinations to include new areas, including more on roentgenographic interpretation and its application to treatment planning, we as teachers will have more criteria by which to judge the results of our teaching efforts. This in turn, may cause us to modify our undergraduate curriculum. This particular influence may or may not be desirable.

A course in dental radiology does not usually have any prerequisites. Since all study of dentistry follows a prescribed sequence of courses, the curriculum does provide an orderly progress through various subjects. Chemistry, physics, anatomy, histology, biochemistry, and many times pathology are usually offered in the curriculum prior to the course in radiology. These basic courses, in addition to those within the dental clinical curriculum, should prepare the student so that he can develop rapidly his technical and interpretative abilities in order that he may adequately meet the problems encountered in the general practice of dentistry. The correlation of knowledge gained in earlier courses and the dissemination of new information particularly pertinent to radiology are the prime responsibilities of the radiology teacher.

THE RESPONSIBILITY OF THE DENTAL PROFESSION IN REDUCING EXPOSURE TO IONIZING RADIATION

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As one examines the relationship between dentistry and that aspect of public health work which concerns itself with public exposure to ionizing radiation, one becomes aware that dentistry has at least four areas of responsibility: (1) to recognize that radiologic health responsibilities actually exist; (2) to provide educational opportunities for the members of the profession in areas of radiologic health pertinent to dentistry; (3) to be certain that dentists avail themselves of such educational opportunities and use this new knowledge in routine office work; and (4) to defend dentistry's right as a member of the health science team to make its own decisions as to when and how much ionizing radiation should be used as an integral part of dentistry's effort to maintain and improve the health of the nation.

Dentistry's first responsibility in the area of radiologic health is the recognition of the fact that a real responsibility to the public does exist. The use of x-rays in dentistry has been accepted by the average practitioner with little or no consideration of the dangers. This is understandable. It was recognized early that the x-ray film could be an indispensable tool in oral diagnosis. Since approximately 1935 or 1940, a dental office not equipped with at least one dental x-ray machine has been judged unprogressive or unmodern. X-ray equipment was accepted as one of the many improvements of a mechanical nature which have been made available to the dental practitioner during the last several decades. It must be remembered that many dentists, particularly those who graduated from dental school prior to approximately 1940, did not have the same educational opportunities that have been made available to our present dental graduates. Formal courses in oral roentgenology were generally not available; instead, a few rather sketchy talks on technique were included in the over-all lecture series in oral diagnosis. Because of this, many dentists are self-trained in the use of x-radiation. Even now, organized dentistry does not recognize the specialty of oral roentgenology. Each dentist is his own "roentgenographic specialist." His excellence in the technical and interpretive phases

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of oral roentgenology is never questioned. Because of this, his tendency to keep up with the development of new knowledge and to implement knowledge by practical office usage is limited.

Specifically in the field of radiologic health, the dentist has not been given authoritative opinions or advice until very recently. After all, x-rays are invisible and their deleterious effects often become evident only after a long latent period. Even then, the tissue effects of excessive ionizing radiation may be masked by other more clinically evident biologic changes. Members of the health sciences, other than those practicing the specialty of radiology, have not appreciated fully the seriousness of the situation. Thus, initial efforts of the dental profession should be toward developing in the mind of each dentist a conviction that he has a personal responsibility for avoiding improper use of ionizing radiation.

It seems as though this awareness of the problem could be aroused by emphasizing that (1) medicine and dentistry are accountable for whole-body radiation to the extent of equaling or slightly exceeding that received from background sources and (2) it now appears that somewhat less than one-half of the "spontaneous" mutations in man are caused by radiation from these (background) sources.[1] If these statements are true, and there is at present no evidence to suggest that they might not be, it becomes obviously important to limit unnecessary radiation as much as possible without delimiting that amount of radiation which is essential for diagnostic procedures of dentistry and the diagnostic and therapeutic measures of medicine. If this is not done, it is difficult to see how the population's spontaneous mutation rate can be prevented from increasing. This is especially true since our civilization protects those who are physically or mentally deficient rather than subjecting them to Nature's law of "survival of the fittest."

Untoward radiologic effects of dentally produced x-radiation are probably largely genetic in character, except for the personal harm that may befall the dentist and his employees and possibly specific area radiation of the patient's eyes and thyroid gland when slow film, with no collimation or filtration, is used. While American dentistry contributes minor amounts of gonadal radiation per person, it does add, through the use of its 95,000 x-ray machines, to the gonadal radiation of the population as a whole. It must do everything possible to reduce substantially the amount of radiation that it creates. There are some who take the view that medicine and dentistry together are allotted a certain amount of "permissible" radiation to which the public may be exposed. The philosophy exists that dentistry is "entitled" to its fair share of this amount and that, since dentally produced gonadal radiation does not approach this so-called "share," there is no particular need for dental practitioners to be concerned. Such ideas must not be permitted to persist.

It is of interest to contemplate the *actual* amount of gonadal radiation which dentistry does contribute to the *over-all* population. Interpolating from Stanford and Vance's[2] work on gonadal exposure from dental films, we find that 1 milliroentgen of gonadal radiation is produced for each roentgen of facial

exposure. Older types of dental x-ray machines, and these make up the majority of those presently in use, have an output in air of approximately 2 r per second (10 Ma., 60 to 65 KVP) at the tip of the pointed plastic cone (skin) if no additional filtration has been added. Since the average exposure time for a fourteen-film complete mouth survey (the minimum number in dentistry) is from twenty-three to twenty-five seconds, it can readily be seen that a total of 50 r is produced per complete mouth x-ray with a maximum gonadal dose of 50 milliroentgens. These figures are based on the use of medium-speed dental films. Richards[3] differs with Stanford and Vance by a factor of 10 and says that 0.1 milliroentgen reaches the adult male gonads for each roentgen produced at the face. He goes on to say that, using optimum technical factors, only 2.14 milliroentgens of absorbed tissue dose will reach the gonads of the adult male during the making of a fourteen-film complete mouth roentgenographic survey. (In his work medium-speed rather than the fastest films were used.) These figures were based on the use of twenty-eight seconds of exposure for the complete survey and could presumably be reduced by a factor of 4 if the fastest films were used. This decrease in radiation would result in a gonadal absorbed dose of approximately 0.5 milliroentgen.

Thus, estimates of gonadal dose in the adult male from a complete mouth survey of fourteen films appears to vary from 0.5 milliroentgen to 50 milliroentgens, a factor of approximately 100. This difference could actually be increased if regular-speed (the slowest type of dental film) instead of the medium-speed films were used in computing gonadal dose on the basis of Stanford and Vance's work. Regular film is approximately two and one-half times slower than the medium-speed film. These considerable differences in gonadal dose estimates are based on variations in research techniques, the speed of the films used, and such mechanical aids as diaphragms for beam collimation, filtration, minimization of exposure times accompanied by prolonged developing, the use of open-end dental cones instead of the pointed plastic cones, etc.

If one recognizes that there are some 95,000 dental x-ray machines in the United States and agrees that, conservatively, an average of twenty films are taken on each machine per day,* one realizes that the *daily* gonadal dose is being distributed by dentists to the *total* American population (180,000,000) is between 76 and 6,000 r. (20×0.04 mr per film of gonadal radiation $\times$ 95,000 = 76 r; 20×3.16 mr per film of gonadal radiation $\times$ 95,000 = 6,000 r. The 0.04 mr per film was determined by dividing fourteen films into 2.14 mr per complete mouth, as suggested by Richards, and further dividing by 4 to interpolate from medium-speed film to the fastest film available. The figure of 3.16 mr was determined by dividing fourteen films into 50 mr as calculated according to the work of Stanford and Vance.) It must be re-emphasized that the lower figure of 76 r implies that all dentists employ all possible radiation-limiting potentials, while the higher figure suggests that little or no care is taken other than using medium-speed instead of slow film.

*This is a totally subjective estimate. Statistics on the sale of dental films over the last thirty years could help materially in obtaining more valid information in this regard, but such information is difficult, if not impossible, to obtain from the manufacturer.

On the basis of a population of 180 million and an estimated 3.5 r of background radiation in a thirty-year period to the average person in the population, one can calculate that the total background radiation delivered per day to the entire population is approximately 57,500 r.

On a percentage basis, therefore, dentistry appears to add to the population's total daily gonadal dose from 0.1 to 10 per cent of that being received daily through background radiation. It is probably reasonable to estimate that dentistry is adding presently about 7 per cent of background to the average person's background dose. This figure is likely to decrease as more dentists utilize radiation-reducing methods.

Figures, like statistics, are known to lie. Such figures presume the absolute lack of any type of tube-housing leakage; they are averages and do not take into account the age of the person being exposed; they overlook the possible relatively large doses that might be given to some persons in order to bring the population's average dose to such figures as have been stated; in this same vein, they overlook the fact that living standards and the economic statuses among the American people differ sharply. Radiation usage in dentistry is likely to be directed largely to that group which has the ability to pay for dental services.

There are those who will say that the use of total population figures of 180 million is not valid. They will point out that these statistics should include only children and adults of child-bearing age. If one wishes to calculate daily total background for a segment of the population, such as the 20- to 30-year age group, one should use the number in this group as a multiple, instead of 180 million. Similarly, in calculating dentally created gonadal dose for this group, one uses the size of the group rather than the total population number. Such calculations assume that persons in all age groups receive the same amount of radiation from dentistry. This is not the case. The very young and the aged are probably radiated least. However, from the age of approximately 8 years, American children receive about the same amount of radiation from dental x-ray machines as do adults. Objective statistical information of this type is difficult to find in the literature.

Unfortunately, dentistry has within its membership some who adopt an "it-can't-be-true" attitude toward the biologic effects of x-radiation. Fortunately, this number is constantly decreasing. It is amusing to contrast the attitudes of such dentists with the actions of the minority lay groups who are opposed to water fluoridation. To these minority lay groups, the dentist says, "You are not competent to judge whether or not fluorine in small quantities shall be placed in your drinking water. We, the dental scientists, are the experts. You should accept our opinions." Then, by contrast, some of this same group of dentists take the prerogative of objecting to the opinions of the geneticists and the biologists who are now the experts in ionizing radiation effects. This lack of objectivity is no doubt human and to be expected, and dentistry must simply contend with this group in the best way that can be devised.

Certainly, the thinking members of the dental field recognize the indefiniteness of the future with respect to ionizing radiation and are increasingly beginning to accept the need for conservatism in the use of ionizing radiation at all levels.

The second responsibility of organized dentistry is to provide educational opportunities designed to further the dentist's knowledge of radiologic health. By and large, this is being done effectively—but to varying degrees. The American Dental Association, in conjunction with the National Bureau of Standards, has produced a film on x-radiation designed to enlighten the dentist about the physical properties and the dangers of ionizing radiation. The American Dental Association has cosponsored a booklet prepared by the American College of Radiology entitled *A Practical Manual on the Medical and Dental Uses of X-rays With Control of Radiation Hazards.* Various educational activities at the district and state dental society levels have been started for the prime purpose of restricting the excessive use of x-radiation. Surveys have been made in several cities to determine the common practices of dentists relative to the use of x-radiation, and filters and diaphragms together with educational booklets have been provided the dentists at little or no cost. It is pertinent to point out here that two members of the Division of Radiological Health of the United States Public Health Service have only recently concluded a two-week tour of the state of Alabama, making available to the dentists, by districts, basic information about radiologic health. The American Dental Association has encouraged the publication in its *Journal* of suitable articles designed to acquaint the practicing dentist with his responsibilities, and to some extent formal courses (in contrast to district dental society meeting talks) have been offered by dental schools or by dental groups. At the undergraduate and graduate levels of dental education, every effort is made to inform the students of their radiologic health liabilities as dental practitioners.

The third trust placed upon the dental profession is that of assuring the public that dentists are taking advantage of the available educational opportunities and are using all possible radiation-limiting means in the conduct of their dental practices.

In conjunction with this assignment, it is pertinent to ask: "For 'what' is the dentist responsible?" The answer need not be vague nor evasive. The dentist is responsible for becoming informed about the type of radiation that he is using and competent in reducing tissue exposure as much as possible without limiting the availability of necessary diagnostic information. The dentist can acquire this competency without undue expenditure of either time or funds.

Questions are sometimes raised as to whether or not it is necessary to delve deeply, at an instructional level, into the physical and biologic aspects of the problem as opposed to providing only technical information which could be employed by the dentist in reducing the amount of ionizing radiation reaching his patient. Perhaps an analogy can be drawn between this problem and driving an automobile. One can drive an automobile without knowing how the carburetor functions or the order of cylinder firing. One cannot survive without

a knowledge of the traffic laws. If a knowledge of auto mechanics were essential to an understanding of the traffic laws, it would be important for the driver to learn such details. Perhaps we can teach the dentists the "laws" in an absence of an understanding of fundamentals, but this is doubtful. At any rate, it is doubtful whether the dentist would continue to comply with empirical methods. He must understand the rationale behind the changes which he is being asked to incorporate into his office procedures. To some extent, office practice can be legislated; basically, however, care of patients must be left to the individual practitioner. He will do his best if he understands and is concerned.

Having obtained information about radiation-reducing methods, it is essential that these measures be used. Most dentists will make the necessary technical changes immediately; a few will not. It becomes the duty of organized dentistry to police its membership in order to be certain that the public is being protected. This should be done at the state and local levels with appropriate encouragement from the national organization. Again, there may be those who say that organized dentistry is not obliged to police its members on the management of radiation. Herein lies a difference of opinion. I feel that the dental profession should accept a responsibility for the ethical and professional conduct of its members. Radiation matters constitute only a segment of the total responsibility.

The dentist is responsible to the public and, of equal importance, to himself and to his assistant or to his office personnel. Since individual dentists do not generally use radiation in excess of the amount employed by the general practitioner, the American Dental Association has not been able to compile statistics on the life span and the causes of death of dental roentgenologists. There is reason to suggest the possibility, however, that there may be an increased incidence of leukemia and possible life-shortening as well as genetic effects among the members of the dental profession.

The dental profession may also become responsible to policing agencies as a result of legislative actions. To some extent, this is not unreasonable, provided that such legislation is limited to the mechanics of the science and does not restrict the right of the practitioner to act on the basis of his own judgment. This leads to the fourth responsibility of dentistry.

The dentist, as a member of the health science team, must be the soul judge of the amount of radiation to which his patient shall be subjected. This statement, of course, is based on the premise that the dentist's judgment, experience, and knowledge are well founded and that he will use these attributes in limiting, wherever possible, the amount of irradiation to which his patients are exposed. Legislation designed to control the use of ionizing radiation exists or is in the process of being formulated in a number of states.[4] The public is entitled to legislation of this type so long as it does not infringe upon the professional prerogatives of the dentist. Although it would be more advisable to regulate on a voluntary basis, there is no reason why the dentist cannot be required by law to properly filter and collimate his usable beam of x-radiation. A policy

of requiring a dentist to use the fastest possible film, when in his opinion a somewhat slower film provides him with a better diagnostic result, is open to question. Subjecting the dentist to regulation which would limit the number of films he is to take or the frequency of intervals between exposures would seriously impair the quality of the health service that he is now able to provide.

The dental profession has shown interest in that area of radiologic health that is directly related to dentistry. The profession will continue to cooperate by doing all that it can to maintain and improve the health of our nation's people.

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Availability of Teaching Slides in Oral Roentgenology

It is with considerable pleasure that the American Academy of Oral Roentgenology announces the availability of teaching slides from the personal collection of Dr. Edward Stafne of Rochester, Minnesota. Dr. Stafne has made available considerable material for reproduction. The exact mechanics of reproduction have not been developed as yet, but persons interested in obtaining this material for teaching purposes can correspond with Dr. Waggener at the College of Dentistry, University of Nebraska, Lincoln 8, Nebraska.

During the annual business meeting held in October, 1960, Dr. Donald Waggener reported that the crest of the Academy had been reproduced on 2 by 2 inch slides and that these slides were available without cost to the members of the Academy. Although no 3¼ by 4 inch slides of the seal are presently available, it was felt that they could be procured from the same source.

ROENTGENO-QUESTIONS

How can the x-ray image in a greatly overexposed film be seen?

When a film is overexposed to such a degree that the entire roentgenogram looks black, there is more than one way available for the operator to see the roentgen image. The first and most simple way is to increase the illumination used for viewing the film. In other words, use a much stronger bulb or source of illumination in the view box. In this instance, the film under observation should be properly masked to prevent glare from the periphery of the bright view box.

Two other methods are practical, and both of these methods permit visualization through a reduction of the density of the roentgenogram. The first involves the use of a chemical reducer. These chemical solutions are available commercially and will reduce the density of the overexposed roentgenogram. The second method of density reduction is also simple. This is done through the removal of one of the emulsions on the film. Dental films have two emulsions, one on either side of the film base. The emulsions are resoftened in the developer and one emulsion is removed mechanically. Refixing will harden the remaining emulsion, which will now give a roentgenogram with half the density of the original.

The American Academy of Oral Roentgenology solicits from the readers of ORAL SURGERY, ORAL MEDICINE AND ORAL PATHOLOGY any questions which deal with technical or interpretive aspects of oral roentgenology. These questions should be sent directly to the editor of this section, Dr. Arthur H. Wuehrmann, School of Dentistry, University of Alabama Medical Center, Birmingham, Alabama; the editor will distribute them for reply to a suitable group within the Academy. Questions, with the answers, will be published at as early a date as possible in "Roentgeno-Questions." Questions, especially those of an interpretive nature, should ordinarily be accompanied by good-quality roentgenograms and a pertinent history. The names of the questioner and the respondent will not be published.

ROENTGENO-ODDITIES

Double Exposure—A Bizarre Effect

THIS reproduction of lower anterior teeth demonstrates a double exposure where, coincidentally, the film was inverted and the tooth roots accurately superimposed. The mottling that can be observed on the crowns of the three teeth in the center is due to the trabecular pattern of supportive bone which

is burned out in all areas other than those directly over the tooth crowns. The only interproximal bone observable in this film occurs in the area that was covered by bone during both exposures.

Clay C. Hunley
New Orleans, La.

Each month this section will bring to the readers of ORAL SURGERY, ORAL MEDICINE AND ORAL PATHOLOGY one or more roentgenograms which demonstrate unusual, unexpected, rare, or bizarre roentgenographic changes. These roentgenograms will be accompanied by an explanation or by words of inquiry regarding the particular change. All films used in this section will be accepted with the understanding that 2 by 2 or 3¼ by 4 inch slides or glossy photographs of the films will be made available to interested readers through the editor of the American Academy of Oral Roentgenology at the individual's expense. The cost will involve only the photographer's charges. Each slide or print will give credit to the donor. Interesting roentgenograms are solicited from all sources. Please be certain to identify your films properly so that they can be returned. All material for publication should be submitted to Dr. Arthur H. Wuehrmann, University of Alabama School of Dentistry, Medical Center, Birmingham, Alabama.

ORAL PATHOLOGY

General Section

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ABERRANT SUBMAXILLARY GLAND TISSUE PRESENTING AS A CYST OF THE JAW

Report of a Case

Harry Hayes, M.D., New York, N. Y.*

RADIOLUCENT areas in the jaw are encountered often in dental practice, usually as a result of routine roentgenographic examination for dental disease. These areas have been studied extensively and can be classified into several large groups. The present report deals with a case treated at the United States Army Hospital, Fort Chaffee, Arkansas. It was felt that, because of its unusual nature, this case should be reported.

Examples of the usual types of radiolucent area with a definite margin encountered in the jaw are the radicular cysts and the dentigerous or follicular cysts. There are many other types of cystic lesion which are seen much more rarely. These include the granulomas, adamantinomas, benign giant-cell tumors, and traumatic cysts. In most cases, the size, location, radiographic appearance, and presence or absence of symptoms can lead one to the correct diagnosis before surgery is undertaken. The pathologic aspects, the diagnosis, and the management of such cysts are fairly well appreciated and are well described in textbooks of oral pathology and oral surgery; these aspects, therefore, will not be discussed in any detail here.

CASE REPORT

A 56-year-old retired Army officer was admitted to the United States Army Hospital at Fort Chaffee, Arkansas, on Nov. 3, 1958, for construction of dental plates. The patient had a past history of considerable dental caries and had undergone multiple extractions over the past several years. Roentgenograms of the jaw, made on admission to the hospital, revealed a cystic lesion at the left angle of the mandible (Fig. 1).

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There was no further history relative to this cyst. The past history revealed a hiatus hernia which had been controlled medically and diverticulosis of the sigmoid colon which was asymptomatic. The patient had sustained fractures of both bones of the left forearm in childhood. The remainder of the history was noncontributory. The physical examination revealed a well-developed, well-nourished white man in apparent good health, with normal vital signs and no physical abnormalities.

Fig. 1.

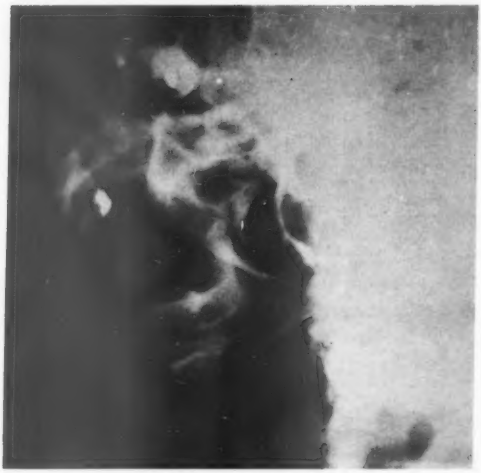

Fig. 2.

Routine laboratory data, liver profile, electrocardiogram, and complete barium studies were within normal limits. A long-bone series was normal except for evidence of healed fractures in several long bones.

On Nov. 12, 1958, under endotracheal anesthesia, a skin incision was made slightly below the angle of the left mandible. By sharp and blunt dissection, the angle was exposed and the periosteum incised and reflected. By means of both sharp and blunt curettes, the thin plate of cortical bone over the cystic area was removed. This revealed a smooth, solid, well-circumscribed mass of tissue of rather soft consistency which was easily lifted out of the bony defect, thereby disclosing an absence of the underlying lingual aspect of the mandible. Several thin adhesions were divided during removal. Bleeding points were clamped and ligated. After the mass had been removed completely, the overlying periosteum was approximated and the wound was closed in the usual manner.

There was moderate swelling in the area for about one week, but this subsided spontaneously. The sutures were removed on the seventh postoperative day. The patient was asymptomatic on discharge on Nov. 20, 1958. On return visits to the dental clinic, he stated that the dental plates were very satisfactory. The postoperative roentgenograms showed ossification of the defect (Fig. 2).

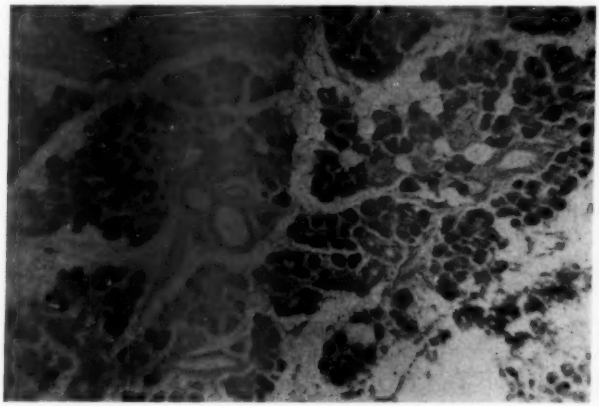

Fig. 3.

The pathologist's report on the excised tissue was as follows: "The tissue consists predominantly of salivary gland tissue. Most of the glands are albuminous, but a minority are mucous. Abundant fat is interspersed between lobules of gland. Bundles of fairly dense collagenous connective tissue are present. Even in some of these, submaxillary gland tissue is present. Multiple sections demonstrate essentially the same pattern." (Fig. 3.)

Diagnosis: Ectopic salivary gland tissue in the mandible.

A review of the literature reveals two cases similar to the one described. Jacobs[1] presents several examples of mandibular embryonic defects, one of which, on exploration, was found to consist of a recess in the lingual surface of the mandible in which a part of the oral lobe of the submaxillary gland was lodged. Richard and Ziskind[2] report a case of a radiolucent area in the region of the lower left cuspid and premolar which, on exploration, was found to consist of salivary gland tissue, probably arising from the sublingual gland. No other specific reference to this entity could be found in the literature although most of the major textbooks on oral disease mention the occasional occurrence of

salivary tissue in various aberrant locations, including the mandible. Presumably, then, this case represents the second reported instance of submaxillary gland tissue producing rarefaction of the mandible and having the x-ray appearance of one of the more usual types of cyst encountered in this location.

The reason for the aberrant position of this glandular tissue is not entirely clear. There are two possible explanations for this occurrence: Cohnheim's embryonal rest theory offers an attractive possibility, as does Whitmore's metaplasia theory that oral epithelium has a more or less recessive tendency to develop into salivary gland tissue. From the microscopic appearance, it would seem that the glandular elements were functioning and that, in all probability, the secretion drained into the main portion of the submaxillary gland. There was no evidence of malignancy in this specimen.

SUMMARY

A second case of aberrant submaxillary gland tissue presenting as a cyst of the mandible is reported. The diagnosis was not made prior to exploration. It is felt that this lesion is still very rare, since other cases have not been reported.

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TRAUMATIC NEUROMAS

A Review of the Literature

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EARLY in the nineteenth century, Odier[23] described the enlargements or swellings which develop at the distal ends of the proximal segments of peripheral nerves after partial or complete division. He spoke of these as nerve tumors. Since his time, these neural enlargements have been frequently studied. To a great extent, interest in them has been stimulated by wars, which result in a great number of amputations. The painful stumps that remain following amputations necessitated by mutilating wounds or infections made the study of neuromas, and especially the factors concerned with neuroma formation, imperative.

Until recently, only the general surgeon, the neurosurgeon, and the orthopedic surgeon had been concerned with traumatic neuromas. Since the early 1930's, however, reports of traumatic neuromas occurring in the mental and infraorbital nerves have begun to appear in the dental literature. There is little doubt that prior to this time traumatic neuromas had often been the cause of pain in the facial region. These pains, for the most part, either remained undiagnosed or were diagnosed incorrectly. With the emergence of the specialty of oral surgery and the rapid strides made in the field of oral pathology, much additional information relating to the neurological problems associated with the oral region has been obtained. This discussion will include a brief history of traumatic neuromas, the known causes of these neuromas, their gross and histologic structures, their treatment, and a review of the reports in the dental literature pertaining to traumatic neuromas that have occurred in the oral region.

HISTORY

Traumatic neuromas were first described in the medical literature as early as 1811. It was at this time that Odier[23] first described the enlargements or swellings that develop at the distal end of the proximal segment of peripheral nerves after partial or complete division. In 1828, Dr. William Wood[34] described twenty-four cases of neuroma. These included cases in which there were subcutaneous tubercles as well as painful neuromas in peripheral nerves resulting from trauma. These cases included civilian patients as well as casualties from the wars of that period. Smith,[26] in 1849, classified neuromas into two

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primary groups—(1) those of spontaneous origin and (2) those resulting from injuries to nerves, including neuromas found at the cut ends of nerves. On the European Continent, Virchow,[32] in 1863, placed the histology of nerve tissue on an entirely new basis when he divided neuromas into two classifications—(1) the true neuroma and (2) the false neuroma. The true (neuroma verum) neuroma was defined as a tumor composed mainly of new nerve tissue, or one in which the newly formed nerve tissue was the initial constituent. Virchow described the false neuroma as being composed of mainly connective tissue derived from the sheaths of the nerves. He believed that most neuromas were of the true variety but that the frequency of false neuromas had been overstated at the expense of the true neuromas. Observations made since Virchow's time have contradicted this idea. Many more true neuromas than false neuromas have been reported, especially in nonwartime years. Courvoisier[11] regarded the anatomic classification as impractical and used a mixed description. He classified amputation neuromas and other nerve divisions as divisional neuromas. In 1892, Duhring[12] described the first painful neuroma of the skin. In 1920, after World War I, Huber and Lewis[17] published reports of their experimental work in the prevention and causes of traumatic neuromas. Little of practical significance has been done since the work of Huber and Lewis, and most surgical techniques of today are still based on their experiments.[15] Smith's classification of traumatic neuromas has been modified to include only those cases in which the connection between the injury and the tumor is beyond question. In this strict sense, the stump neuromas are probably the most typical examples, although at times they, too, have been alternately described as true and false. The present review is concerned chiefly with what is commonly called the stump, traumatic, or amputation neuroma (names which are derived from the causative factors in its development).

CAUSES OF AMPUTATION NEUROMAS

Trauma to a peripheral nerve results in a particular complete cessation of conduction and produces a disturbance in the motor, sensory, reflex, vasomotor, and trophic functions in the area supplied. Etiological factors may be pressure, ischemia, crushing injuries, cuts, lacerations, stretching, and bleeding into the surrounding tissues.[14] After the nerve fibers have been interrupted, those in the peripheral stump completely degenerate and regeneration proceeds from the nearest node of Ranvier in the proximal portion. The axons swell and become tortuous, fragmenting into small, corkscrew-like segments, and break into smaller pieces. These are engulfed by the mesodermal leukocytes and the neurilemmal phagocytes. In the early stages of regeneration, the cut ends of the axons may split and form ball-like ends which resemble regeneration. The axon and its myelin sheath distal to the point of section disintegrate and are replaced by proliferated Schwann cells. This process occurs simultaneously throughout the peripheral fibers, being more active at the site of trauma.

The cell of origin reacts; it swells and becomes rounded. Its nucleus travels to the nerve periphery, and the Nissl substance of the center of the cell undergoes chromolysis. Axons of the central stump begin to sprout by budding,

forming spirals, spheres, and many collateral processes. The terminal spheres act as battering rams, piercing the Schwann cells and the connective tissue. When fibers reach an obstacle, they either penetrate it or go around it. Those that cannot do either degenerate. So many fibers are produced that when the cut ends are in fairly close approximation an efficient union occurs.

If continuity is not established between the proximal and peripheral stumps, the latter slowly become smaller and the neurilemmal bands degenerate and become replaced by connective tissue. The "frustrated" central axons become embedded in a connective-tissue scar and form the amputation neuroma. When the scar tissue contracts, stimulation of the sensory fibers produces a painful neuroma.

Others feel that traumatic neuromas can be caused by mechanical factors, such as wounds, blows, irritation produced by foreign bodies in contact with or lodged against a nerve, or the fracture of surrounding bone canals. In these cases usually only one tumor results; this is not only a source of local pain, but it can give rise to pain that extends up the trunk of the nerve toward its origin.[26] Stookey[28] believes that, unless prevented, a neuroma can form routinely on any severed nerve. Infections may play a role; however, neuromas have formed in noninfected wounds and in wounds with little or no scar tissue. In this connection, it is interesting to note that when nerves are severed without a limb being amputated, even though they are fixed in scar tissue and callus and have outgrowing neuraxes invading all the contiguous tissues, they seldom give rise to pain similar to that caused by an amputation neuroma.[11] In the older amputation techniques, whole nerve trunks were caught in the amputation flap and stretched over the end of the stump. Corner[9, 10] believes that the contraction of scar tissue about newly formed neuraxes may cause pain by strangulation. This condition will persist until the neuraxes die off. Another possible source of pain occurs in nerve ends which have become fixed to the bellies of adjacent muscles and are drawn up with each contraction.[9, 10] Those neuromas of dental origin usually occur at the mental foramen and the infraorbital foramen. They can occur as the result of severing of the inferior alveolar branch of the mandibular division of the trigeminal nerve during a mandibular resection. Nerve avulsions in the treatment of facial neuralgias are occasionally a cause. Also, in mandibular fractures, neuromas can result when the fragments are malaligned and do not heal in such a way that the mandibular canal continuity is restored.[29] In fact, almost any trauma to the inferior alveolar nerve, such as tooth extraction, fracture reduction, or ostectomy, can be suspected as a cause of traumatic neuroma. Bernier[4] has found that, along with the above-mentioned dental causes, amputation neuromas may develop following the surgical removal of tumors from the major salivary glands.

STRUCTURE AND COMPOSITION

It is interesting to note that, whereas the structural components of traumatic neuromas have been a constant factor, many varied descriptions as to their

composition have been forwarded. Probably the most accurate description of what is normally considered to be a traumatic neuroma has been offered by Huber and Lewis.[17] In their experiments on new techniques to prevent the formation of traumatic neuromas, they give the following description:

> A neuroma indicates an attempt, which is thwarted or blocked by scar tissue, on the part of the neuraxes of a divided nerve to seek the distal segment and thus complete nerve repair. When blocked, the regenerating neuraxes form spirals and end disks and become irregularly dispersed throughout the connective tissue of the bulb. The regenerating neuraxes react on the connective elements of the bulb, which as a consequence, increase in number and maintain their embryonal characteristics longer than is normally the case.

Moore[22] states that amputation neuromas are bulbous masses that develop at the proximal ends of divided nerves following amputations, especially of the lower extremities. He feels that they should be regarded as reactive hyperplasias rather than true neoplasms. Karsner[18] concurs with the idea that these are not true tumors. He holds that the growth represents an elongation of the nerve fibers due to excessive regeneration, the new fibers interlacing and coiling to form a painful mass. Robbins[25] believes that it is merely an excessive fibroblastic reaction. Anderson[1] is of the opinion that amputation neuromas are neuromas incited by trauma to a nerve trunk, causing a growth response of neurofibrils together with a proliferation of Schwann cells. Eventually, the schwannian tumor dominates the condition and is replaced by collagen and connective tissue. Most other writers believe that traumatic neuromas are nodular growths formed at the proximal portion of a severed nerve trunk caused by the active proliferation of the Schwann cells and the nerve sheaths. They agree that it is not a true tumor but, rather, an exaggerated response to nerve injury.[3-5, 8, 29, 32]

Gross Structure.—Grossly, traumatic neuromas are generally oval or oblong in shape, with a remarkable density and firmness. They may vary from the size of a small garden pea to that of a large plum. Meckel[21] has stated that "their size bears a direct ratio to the quantity of surrounding cellular tissue and the length of time that has elapsed since division of the nerve." Smith,[26] however, believes that this form of neuroma ceases to enlarge very soon after its formation and that, having attained a certain size, it remains stationary thereafter, with its volume in direct proportion to the size of the trunk in which it is formed. On being sectioned, neuromatous tissue shows a dense fibrous structure, no vascularity, and a nonuniform disposition of nerve fibers. In some cases the nerve terminates at the upper extremity of the mass; in some the nerve fibers can be traced through the whole length of the tumor; and in others the nerve fibers spread and become incorporated with the fibrous structure of the neuroma. The tumor may even be situated several inches above the site of the injury. The proximal portion of the nerve is usually relaxed. This relaxed state and the removal of the tumor's extremity to some distance from the original cut are probably due to the elasticity of the nerve and its retraction upon being divided. Some authors believe that the enlargements on the ends of the nerves divided in amputations are not common but are found only where healing has

not progressed normally or where the adjacent bone is the seat of some morbid process. Smith[26] is of the opinion that these enlargements occur in every case but that only in rare cases are they a source of severe neuralgia.

In neuromas resulting from mechanical injury to a nerve, the mass is usually solid without the investment of a neurilemma and without any form of a capsule. It is also more likely to form on those nerves that have not been completely severed. In these cases, the neuromas are usually more painful. Duhring[12] described a painful skin neuroma that contained elements of skin, densely packed connective tissue, and nonmedullated nerve fibers. This atypical neuroma had connective stroma interwoven with the nonmedullated nerve fibers. Wood[34] reported similar conditions in subcutaneous tubercles. Similar conditions also occurred in the twenty-four cases of painful neuroma reported by him. These neuromas involved nerves of the extremities and resulted from trauma.

Histology.—Histologically, a neuroma represents an attempt at regeneration on the part of the severed nerve and can form on any severed nerve unless prevented.[28] They may be present without pain or undue tenderness, so it is likely that painful neuromas present additional changes in the nerve fibers of an irritative character not found in the simple enlargements of the nerve ends. There is no noticeable histologic difference between a nonpainful and a painful neuroma. Infections and ascending neuritis have some conection, but neuromas have been found in noninfected wounds and wounds with little or no scar tissue. Also, irritation to the nerve can be exerted not only locally but also much higher. This is evidenced by the fact that in secondary operations, when the nerve is amputated very much higher, in normal muscle planes without scar or infection, painful nerve ends frequently form.

An amputation neuroma consists mainly of proliferated endoneural and perineural connective tissue, neurilemma cells, and regenerating neuraxes. The neurones follow a more or less straight course as they enter the proximal portion of the neuroma, but the fibers then interlace and turn back on themselves. A few fibers may penetrate the connective-tissue cap which forms at the end of the nerve and escape into the surrounding tissue. Numerous end discs and bulbs, called growth cones, are seen; these frequently become extremely large with many branching fibrils. These end discs and branching fibrils show the regenerative power of the neuraxes. When certain neurones encounter resistance, the fibrils turn back on themselves and form spirals within the neurilemmal sheath, curling around the neuraxes from which they have arisen. The amount and density of this resistance determine, to a large extent, the shape and length of the neuroma. In older neuromas, the tissue contracts and sclerosing takes place.[28]

Marinesco,[19] in his study of painful amputation neuromas, has shown that a majority of these tumors manifest evidence of a genralized infective neuritis, endarteritis, periarteritis, perivascular exudation, and infiltration of lymphocytes and leukocytes with the presence of giant cells. In one neuroma, removed

three years after amputation, a low-grade infection with bacteria still present was discovered. In a number of neuromas, minute foreign bodies were also found.

TREATMENT

Almost all methods of treating amputation neuromas prior to the experimental work of Huber and Lewis were based on empirical knowledge. Attempts were made to prevent the escape of neuraxes into the surrounding tissue. Nerve stumps were turned upon themselves and sutured to the parent trunk. Nerves were also split and sutured again to one another. Some surgeons split the parent trunk and passed the nerve ends through the opening and sutured them to the trunk. In an effort to avoid this additional trauma in preventing the outgrowth of the neuraxes, Chapple[7] attempted to turn back a cuff of epineurium, stripping it upward with a piece of gauze and cutting the nerve just below the reflected cuff. After this, the epineurium was brought over the cut surface of the nerve. In that same year (1918), Corner[9, 10] devised the "swinging-door" flap. This prevented the escape of the neuraxes and lessened the possibility of an ascending neuritis. Stookey advocated a combination of Corner's closure and the alcohol injection of Huber and Lewis.

Until the experimental work of Huber and Lewis[17] showed how neuromas were formed, however, little positive progress was made toward the prevention of neuromas. Huber and Lewis reported their experiments on twenty-eight rabbits. In these experiments to determine the cause of neuromas, the operations were performed under strict aseptic conditions, and dissections were made along intermuscular lines to avoid hemorrhage. Thus, the two factors, suppuration and hemorrhage, the consequences of which have been considered so important in the causation of neuromas, were eliminated. In all cases, even with perfect aseptic healing, neuromas developed. It took about nineteen days for the neuromas to develop. Increase in size took place in areas of least resistance. Dr. Lewis had seen one case of a divided nerve in a war wound in which the divided ends had been driven into the bone. No neuroma formed in this case. He believed that the pressure from the surrounding bone prevented bulb formation, which occurs with such frequency that it might be regarded as normal.

In their experiments, Huber and Lewis found that the cut end of the nerve is covered by a connective-tissue cap. This cap occurs regularly in neuromas and indicates the site of the blood clot which forms over the end of the nerve after division. This is transformed into scar tissue by the invasion of connective tissue from tissues surrounding the nerve end, from the endoneurium, the perineurium, and the epineurium. This cap does not completely block developing neuraxes, and many penetrate it and grow into the surrounding tissues. Within six hours after the division of a nerve, there are definite evidences of regenerative activity on the part of the divided neuraxes. Changes in the neuraxes and the connective tissue occur and progress simultaneously, and it seems certain that the developing neuraxes stimulate the connective tissues to increased and continued growth.[17]

Thus, any procedure which is employed with the intention of preventing neuroma formation must be directed against the neuraxes rather than against the connective tissue at the end of the cut nerve.

As was previously stated, the procedure employed in the experiments of Huber and Lewis was tested on twenty-eight rabbits. After division, the trunk of the nerve was injected with absolute alcohol at a point from ¾ to 1 inch above the plane of section. Enough alcohol was injected to make the nerve appear a dull white, resembling a cooked egg albumin. In these twenty-eight rabbits, the following results were recorded. Histologic studies were made 157 days after the injection. By this time, numerous neuraxes, both myelinated and unmyelinated, had passed through the injected part of the nerve to the extreme distal end of the proximal segment. The connective-tissue sheath of the nerves was materially thickened at this point. It extended into the interior of the nerve and separated into small intertwining bundles. Centrally, the neuraxes had a more regular longitudinal course, except for those in close relation with the fibrous sheaths. They coursed along the inner surface of the sheaths without a definite arrangement. The structural appearances presented were not those of a neuroma. These findings are in marked contrast with those noted after observations made following recognized surgical procedures, which were performed on the end of the nerve. In the "swinging-door" operation, typical neuromas were found four weeks after the operation and also following the crush-and-tie operation.

Since the work of Huber and Lewis, little additional work has been done. The procedures that they developed are still used to great benefit, with little modification.[15]

DENTAL ASPECTS OF TRAUMATIC NEUROMAS

Although traumatic neuromas have been reported in the medical literature for the past century and a half, it has been only recently that mention of them has appeared in the dental literature. As is the case with many diseases and health problems, our medical colleagues, by virtue of the longer history and existence of their professional groups, have a richer store of available information concerning traumatic neuromas. With the rapid progress made in the fields of oral surgery and oral pathology, however, more oral neurological problems are being recognized and their solutions searched for.

In oral surgery, the symptoms of traumatic neuroma may arise following injury to the inferior dental nerve, the auriculotemporal nerve, the peripheral branches of the maxillary division of the trigeminal nerve, nerve fibers pressed against bone, inclusion of nerves in the ligation of an artery, and the involvement of the nerve in scar tissue.[30] They have also been known to occur as the result of the removal of teeth. Occasionally, this condition is observed after a Caldwell-Luc operation, in the course of which the infraorbital nerve may be traumatized by retraction of the lip or by an excessive separation of the periosteum in the area surrounding the infraorbital foramen. Severe blows to the head, especially when associated with fractures of the base of the skull,

may injure the Gasserian ganglion and set up a chronic pain in the facial areas. As a rule, persistent, unpleasant paraesthesia in the area surrounding the mental foramen is a diagnostic sign of the presence of a traumatic neuroma.[2]

In zygomatic-maxillary bone fracture, the break often involves the infraorbital foramen.[27] Anesthesia of the ala of the nose and the upper lip is so common that whenever it is present after a facial injury, a fracture should be suspected. In a great majority of the cases, the effect of the nerve injury is transient. There are some cases, however, in which a painful neuroma develops and has to be treated by excision of the nerve at the infraorbital foramen.

Thus far, five cases of traumatic neuroma have been reported in the dental literature. In each of the five cases the diagnosis was based chiefly on the report of the pathologist. Probably the earliest report of a case of traumatic neuroma was made by Cahn[6] in 1937. In his case, a neuromatous formation occurred in the mental foramen area of a middle-aged, edentulous patient. The pain radiated up the side of the face and into the eye on the affected side. Upon removal, the pain disappeared. The pathologist's report revealed the structure to be a traumatic neuroma. The neuroma was removed by electrocautery, with no apparent consequences. Cahn is of the opinion that a difficult tooth extraction in the vicinity of the mental foramen can result in a traumatic neuroma and that many of the reflex neuralgias in the facial region may be caused by unsuspected neuromas. To prevent the recurrence of a neuroma, he recommends blocking the foramen with a sterile plug of an inert material.

In 1948 Oringer[24] reported a second case of traumatic neuroma. The patient's chief complaint was a profound paresthesia on the lower right side of the face. The slightest pressure caused by the contact of food produced a severe exacerbation of pain. Previous history revealed that one and one-half years earlier the lower right first molar had been removed surgically, with a resulting paresthesia. Perforation of the mandibular canal resulted in the proliferation of fibrous tissue and nerve fibers through the bone into the overlying mucosa. A histologic report showed the presence of a great deal of nerve tissue and connective tissue. The pathologist's report was neuroma of the mandible.

Green,[13] in 1953, reported the removal of an amputation neuroma from the mental foramen region. This had occurred two years after the removal of a "nerve tumor" in the same area. The lesion consisted of a small nodule in the lower right buccolabial vestibule at the level of the mental foramen. Treatment consisted of avulsion of the nerve.

McKay,[20] in 1957, reported a case in Belfast, North Ireland. A painful intraoral swelling of several years' duration suddenly began to grow rapidly following removal of a tooth root. All the other teeth had been removed forty years before, and the alveolar ridge was greatly resorbed. A fingerlike mass was attached to the crest of the lower ridge in the molar region. The lesion was broader at its base than in other areas. It was removed by dissection

from the mucoperiosteum; the mental foramen was not seen. Histologic section showed an interlacing of bands of nerve fibers separated by fibrous septa; hence, a diagnosis of traumatic neuroma was made.

Hecht,[16] in 1957, reported a case in which a patient had undergone surgery of the mental foramen region at the age of 15. Forty-eight years later he developed an alveolar abscess in the same area. The offending tooth was removed. Subsequent excision of the mass of tissue from the mental foramen area produced tissue which, upon microscopic examination, proved to be a traumatic neuroma.

Thoma[30] has reported a case in which a traumatic neuroma resulted from the malunion of a fracture. A patient with an edentulous mandible had sustained bilateral fractures. A head bandage had been used to immobilize the jaw, and this resulted in poorly aligned fragments. Six months after treatment of the fractures, the areas around the fracture sites became tender. The patient complained of intermittent burning pain, with numbness of the lower lip and alveolar ridge. X-ray examination showed old fractures on both sides of the mandible that had united. Malunion on both sides had prevented the inferior alveolar nerve fragments from reuniting. Both fracture sites were treated in the same manner. Windows were cut out of the bone overlying the inferior alveolar nerve. When it was fully exposed and freed from the surrounding connective-tissue fibers, the mandibular canal was repaired at the fracture sites and the nerve ends were placed in proper position. Two months later normal sensation began to return to the mandible.

SUMMARY

The recent frequency of reports of traumatic neuroma in the oral surgery literature has made a better understanding of this subject necessary. In this article, I have attempted to present a brief history of the work done on traumatic neuromas and to point out what various authors believe to be the causes of these abnormalities. Much confusion has existed as to just what constitutes a traumatic neuroma, but I feel that the work of Stookey and of Huber and Lewis has done much to clarify this difficulty as well as to lay down some very definite principles concerning the prevention and treatment of neuromas. Most of this knowledge can be applied to the neuromatous structures occurring in the mental foramen area and the region around the infraorbital foramen. As a greater number of cases is reported, our knowledge of these oral neurological problems will expand and we will thus be able to treat them much more effectively.

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HISTOLOGIC CHANGES IN DENTAL PULPS OF DOGS AND MONKEYS FOLLOWING APPLICATION OF PRESSURE, DRUGS, AND MICROORGANISMS ON PREPARED CAVITIES

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DAMAGE to the dental pulp has been produced by drugs, filling materials, microorganisms, thermal changes, electrical stimuli, and physical injuries to the tooth or adjacent tissues. Preparation of a cavity may, in itself, involve sufficient physical injury to induce changes in the pulp.[1] The extent of the damage depends on such factors as the traumatic effect of the burr, the heat generated by the cutting instrument, the depth of the cavity, and the resistance of the individual pulp.[2] The trauma from operative procedures becomes greater as the floor of the cavity gets closer to the odontoblastic layer.[3, 4]

Studies have been made of damage to the pulp following use of various types of burrs and ultrasonic instruments,[5-8] high-speed cutting,[9] coolants,[10] silver nitrate,[4, 11-17] phenol,[18, 19] and sodium fluoride.[20, 21] The irritating effects of a drug on the pulp are increased if the drug is sealed in the cavity and the duration of contact with the freshly cut odontoblastic processes is prolonged.[4, 14, 20] Pulpal inflammation, once initiated, may attract and fix bacteria present in the blood during a transient bacteremia.[3] Presumably, the entrance of bacteria into an already inflamed pulp would tend to aggravate the inflammation.

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Recently,[22] we sealed a suspension of *Streptococcus faecalis* into deep cavities and found that the bacteria could penetrate the dentine and enter the pulp. Microorganisms were recovered much oftener after pressure was applied to the dentine than when no pressure was used. Thus, pressure might indirectly be a factor in pulp inflammation. The question of whether pressure might also be a *direct* factor arose.

In the present study, our purpose was to observe any histologic changes in the dental pulp which might develop after application of pressure (either alone or in conjunction with microorganisms, silver nitrate, or phenol) to prepared cavities in the teeth of dogs and monkeys.

MATERIALS AND METHODS

The experimental animals were four healthy dogs and three *Macaca rhesus* monkeys, each about 1 year old. Cavities were prepared on the labial or buccal surfaces of twenty-two teeth in each animal with steel burrs operated by a portable dental engine at 6,000 to 8,000 r.p.m. A constant stream of warm water was played on each tooth during cavity preparation.

The teeth on one side were treated by the application of test materials to the prepared cavities, without added pressure, as follows: (1) brain-heart infusion broth for one minute; (2) a twenty-four hour suspension of *Streptococcus faecalis* for one minute; (3) Howe's ammoniacal silver nitrate solution for one minute, followed by reduction with eugenol; or (4) Howe's ammoniacal silver nitrate solution or phenol for 1 minute followed by application of a twenty-four hour suspension of *S. faecalis* for one minute. Each cavity was dried after treatment and was filled with amalgam.

The teeth on the other side were treated in exactly the same way, except that a force of 6 pounds was exerted on the base of the cavity after application of the test materials but before the drying and filling. The pressure device consisted of a spring scale with a serrated, flat head which had been fabricated especially for this experiment. The head was designed to fit on the end of the scale so that a measured force could be delivered to the base of the cavity. All procedures were carried out in duplicate.

In several instances the pulps were accidentally exposed, but the procedures as described were nevertheless employed. In two dogs, we performed a supplementary experiment in which cavities on both the pressure and nonpressure sides were treated with phenol before the application of bacteria and compared with control cavities which had been treated with phenol alone.

The animals were killed by perfusion with fixatives at various intervals after the operative procedures, according to the following schedule: two hours, fourteen hours, one week, and one month for the dogs; two hours, one day, and one week for the monkeys. The animals were decapitated, and each tooth was removed from the jawbone by means of a band saw. The specimens were decalcified. Some were sectioned by the freezing microtome, and the rest were embedded in celloidin and sectioned. The sections were stained with hematoxylin and eosin for microscopic examination.

CRITERIA FOR EVALUATING PULP DAMAGE

In reading the slides, we considered early odontoblastic changes, late odontoblastic changes, and changes within the deep pulp tissue. Our judgments were based on criteria set forth in the following description of typical histologic changes associated with damage to the dental pulp.

Early Odontoblastic Changes.—Initial damage to the pulp by operative procedures is first manifest in the odontoblastic layer.[23] It occurs as a result of injury to the protoplasmic processes of the odontoblasts during preparation of the cavity.

Nuclear changes: The nuclear changes in the odontoblasts include pyknosis, karyolysis, fragmentation, and formation of nuclear vacuoles. These changes are similar to those found in degenerating nuclei of cells in other tissues and signify either that the cell has undergone necrosis or that necrosis in imminent.

Cytoplasmic changes: The cytoplasm of the odontoblasts gives indication of imminent degeneration by becoming granular.

Altered arrangement of the odontoblasts: Odontoblasts are normally parallel to each other. They are lined up regularly in palisade formation (like fence stakes) and are in continuous contact. Trauma disturbs this arrangement of the odontoblasts so that they tend to become disoriented and discontinuous.

Reduced width of odontoblastic layer: The odontoblastic layer becomes narrower, as there is a reduction in the number of cells because of atrophy of the odontoblasts.

Displacement of nuclei: The odontoblastic nuclei may be displaced into the predentine or dentine if there has been pronounced damage. The cause of such displacement is not known. It might be caused by drying of the dentinal tubules or by pressure arising within or outside the pulp.

Replacement by connective tissue: If the odontoblasts are destroyed, they may be replaced by connective tissue. Such replacement occurs as a result of severe damage or of nutritional deficiencies, such as avitaminosis C.

Formation of odontoblast-like cells: New odontoblast-like cells may differentiate from undifferentiated connective tissue cells of the pulp and move into the odontoblastic layer. This process is a manifestation of repair, and it occurs in the later stages of pulp inflammation.

Disruption of the pulpodentinal membrane: The pulpodentinal membrane normally is a continuous, basophilic line at the base of the odontoblasts as they line the predentine. Interference with the continuity of this line indicates that damage to the odontoblasts has taken place.

Vascular changes: Injury causes significant vascular changes in the odontoblastic layer, as follows:

Edema, a leaking-out of fluid from the vessels within the odontoblastic layer, and in many instances in the cell-free zone, shows up in the tissue section as spaces between the odontoblasts. The fluid compresses the odontoblasts

and disturbs or destroys the pulpodentinal membrane. Compression from large quantities of fluid may kill the odontoblasts and the underlying pulp tissue.

Dilation of capillaries, a typical change occurring during the initial stages of inflammation, becomes evident in slides by the sudden appearance of capillaries, previously unnoticed, between the odontoblasts and within the odontoblastic layer. The dilated capillaries are filled with red blood cells. The endothelial cells lining these vessels often appear swollen.

Hemorrhage is common. Red blood cells often can be detected between the odontoblasts and in rare instances may be seen within the dentinal tubules. The red blood cells may also be found in the subodontoblastic layer and within the deep pulp tissue.

The presence of polymorphonuclear leukocytes between the odontoblasts and the predentine is characteristic of severe inflammatory response. Apparently the function of the polymorphonuclear leukocytes is to phagocytize the dead and degenerating odontoblasts and their products. Neutrophils occasionally squeeze into the dentinal tubules.

Small round cells, characteristic of chronic inflammation, may be seen within the odontoblastic layer in the later stages of inflammation.

Late Odontoblastic Changes.—Changes of the odontoblastic layer at a later stage manifest themselves as follows:

Postoperative matrix formation: The *quantity* of predentine may be unchanged, increased, or decreased as compared with the amount present before preparation of the cavity. If the amount of predentine formed is normal, the width of the formed predentine layer remains narrow and conforms to the width on the side opposite that of the cut dentinal tubules. If there has been severe damage, the cells which form dentine matrix (odontoblasts or other undifferentiated connective-tissue cells) may die; consequently, the predentine layer may become narrower or it may disappear entirely. In other kinds of severe damage, predentine is formed more rapidly, the total quantity is increased, and the layer becomes wider. Because of rapid formation, dentine appearing as new spike formation may be observed, or the amount of predentine formed may be so great as to make a layer far wider than that of the predentine in other zones.

The *quality* of predentine is affected. If the injury is minimal, the regularity of the dentinal tubules remains unchanged. If the injury is greater, the predentine is laid down irregularly and may have a jagged appearance or show conelike projections. When damage is severe, the dentine may be atubular or, if predentine is formed with great rapidity, cells or blood vessels may be trapped in the predentine and become manifest as cellular inclusions.

Postoperative calcification: The *degree* of calcification is revealed by the hematoxylin staining. The staining may be regular, indicating normal calcification, or the dentinal tubules may stain lighter or darker, indicating hypocalcification or hypercalcification. Alternate bands of hypo- or hypercalcified dentine, known as calciotraumatic zones, represent periods of lessened and

heightened activity in calcification. The globular *pattern* of calcification may be accentuated. *Inclusions,* such as displaced blood cells, displaced odontoblasts, metal particles, or microorganisms, are sometimes observed in the postoperatively formed predentine or dentine.

Changes in the Deep Pulp Tissue.—Damage to the odontoblasts may cause changes in the deep pulp tissue.

Vascular changes: The classic vascular phenomena of inflammation are evident; these include hyperemia of the vessels, edema, increase in number of neutrophils within the vessels and their margination, red blood cells outside the vessel walls (hemorrhage), and inflammatory cell infiltration of the connective tissue of the pulp and/or of Weil's zone. In acute inflammation, the cells infiltrating the connective tissue are neutrophils; in chronic inflammation, they are lymphocytes, plasma cells, macrophages, and small round cells.

Changes in connective-tissue cells: Loss of viability of connective-tissue cells is indicated by pyknosis and other evidences of nuclear degeneration.

Changes within the ground substance: Special stains, not used in this study, are required for the detection of changes in the ground substance.

Changes in collagen fibers: Collagen bundles may become swollen, or the number of collagen fibers may increase (fibrosis).

Conversion of pulp tissue to granulation tissue: Formation of granulation tissue is a response to chronic inflammation.

Necrosis of pulp tissue: Severe damage causes death of the tissue.

Changes in the intermediate (cell-poor and cell-rich) zones: The cell-poor and cell-rich zones between the odontoblastic layer and the deeper pulp tissue also show inflammatory or degenerative changes. The cell-poor zone is invaded by cells, mainly young fibroblasts or undifferentiated mesenchymal cells. In the cell-rich zone, lesions seem to be mild if the zone remains intact; the lesions are severe, however, if the zone is missing. Repair in this zone is shown by proliferation of fibroblasts, which are oriented toward the odontoblastic layer.

CHANGES OBSERVED IN PULPS OF DOGS' TEETH

Two Hours After Treatment.—Changes in the dental pulps of dogs killed soon (two hours) after treatment were confined almost exclusively to the odontoblastic layer and did not involve the deep pulp. They were correlated mainly with the depth of the cavity and not with pressure or with the action of drugs or bacteria.

Changes in the odontoblastic layer consisted chiefly of morphologic alterations of the odontoblasts (pyknosis, karyolysis, granular cytoplasm, disorientation of odontoblasts, and displacement of odontoblastic nuclei into the predentine), as described in the preceding discussion of criteria. Disruption or interruption of the pulpodentinal membrane was one of the most common manifestations of odontoblastic change.

Among the vascular changes occasionally seen were dilation of capillaries and edema. Dentinal changes occurred only at the site of the cavity cut, where more intense staining with hematoxylin could be observed.

Depth of cavity preparation: In almost every instance the cutting of shallow cavities (remaining layer of dentine thicker than 1.2 mm.) produced little or no change (Figs. 1 and 2). Cutting so as to leave a dentinal layer of less than 1.2 mm. produced changes whose severity was directly proportional to depth. Thus, the teeth with the deepest cavities showed the greatest disorientation of odontoblasts. Displacement of nuclei within the predentine, which seemed to be a function of damage to the odontoblastic layer, occurred in the deepest cavities, whether or not pressure had been applied.

Pressure, drugs, and bacteria: There was no definite evidence that pressure or other irritating factors produced any greater changes in the pulp at this early stage than could be accounted for by the trauma of cavity preparation itself (Figs. 3 and 4).

In teeth treated with silver nitrate, the depth of penetration of silver particles was dependent to some extent upon the depth of the cut. The quantity of silver reaching the pulp via shallow cavities was small, but copious amounts were found in the pulp following application of silver nitrate to deep cavities (Figs. 5 and 6).

Fourteen Hours After Treatment.—Examination of dental pulps in the dog killed fourteen hours after treatment showed that sufficient time had elapsed to permit the development of pathologic changes as a response not only to the trauma of cavity preparation but also to irritation caused by pressure, silver nitrate, or bacteria.

Cavity preparation: Preparation of shallow cavities, without application of pressure or other irritants, was followed by typical odontoblastic changes, but there was no evidence of acute inflammation. Preparation of deep cavities was followed not only by odontoblastic changes but also by dilation and hyperemia of capillaries in the deep pulp (Fig. 7). The capillaries of the odontoblastic layer were hyperemic; they appeared to have increased in number, and in some instances they showed signs of hemorrhage and edema (Fig. 8).

The screening effect of a thick layer of dentine was shown by the mildness of the changes following the application of irritants to shallow cavities. Thus, the application of silver nitrate or pressure, singly or in combination, to such cavities had relatively slight pathologic consequences which were confined mostly to the odontoblastic layer. On the other hand, the same irritants, acting through a thin layer (deep cavities), severely disrupted the odontoblastic layer as shown by disorientation of the odontoblasts, reduction in width of the odontoblastic layer, edema, and infiltration by polymorphonuclear leukocytes; they also caused severe inflammatory changes in the deep pulp tissue, including infiltration of acute inflammatory cells and massive hemorrhages in the incisal portion, which sometimes even involved the other side of the odontoblastic layer.

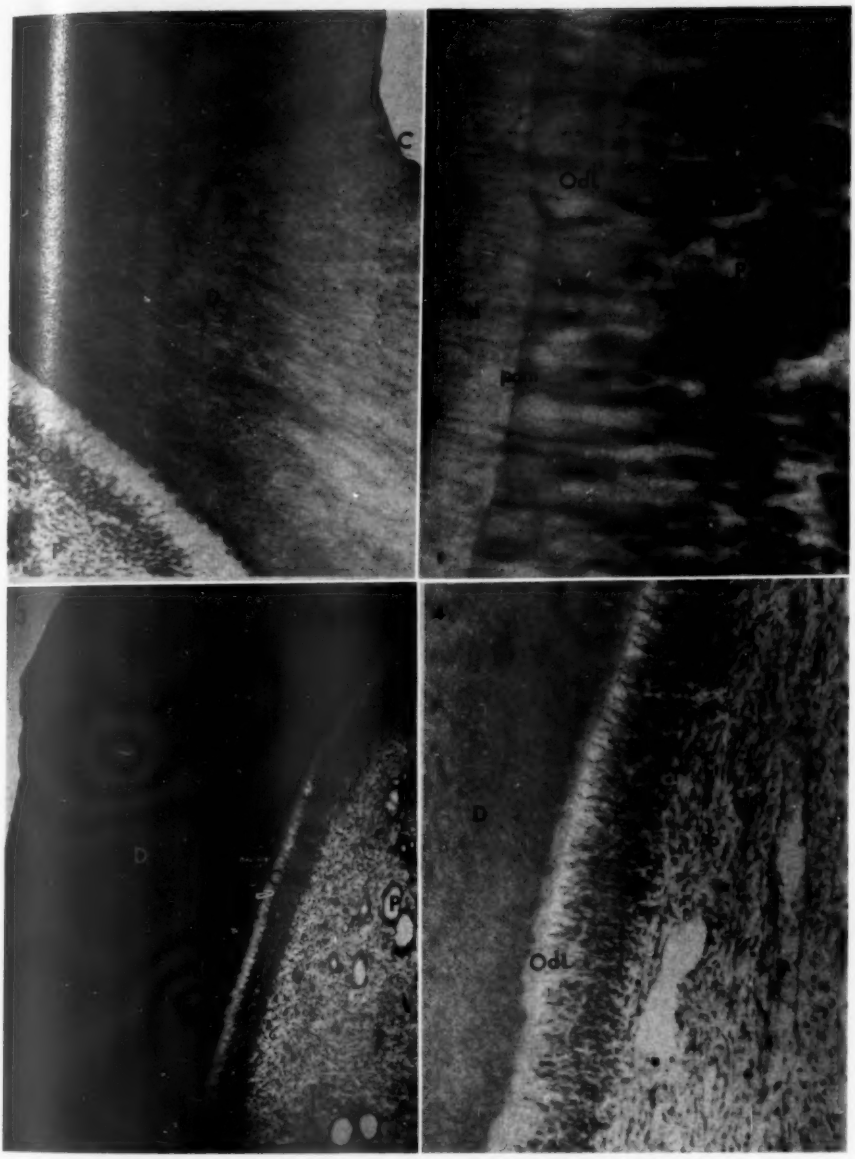

Fig. 1.—Shallow cavity cut in lower left first molar of a dog. The animal was killed immediately after the operative procedures. The odontoblastic layer (*OdL*) is intact and palisaded. *C*, Base of cavity; *D*, dentine; *P*, pulp. (Magnification, ×100; reduced 3/7.)

Fig. 2.—High-power magnification of odontoblastic layer (*OdL*) of pulp (*P*) in tooth with shallow cavity preparation. Pulpodentinal membrane (*pdm*) is intact and continuous. *Pd*, Predentine. (Magnification, ×450; reduced 3/7.)

Fig. 3.—Shallow cavity cut in dentine (*D*) followed by application of pressure. The dog was killed immediately after the operative procedures. *OdL*, Odontoblastic layer; *P*, Pulp. (Magnification, ×35; reduced 3/7.)

Fig. 4.—Higher magnification of odontoblastic layer (*OdL*) of pulp (*P*) of lower left canine of dog. The shallow cavity was subjected to pressure and the animal was killed immediately after the operative procedures. There is some edema and disruption of the pulpodentinal membrane. The pulp is otherwise normal. (Magnification, ×100; reduced 3/7.)

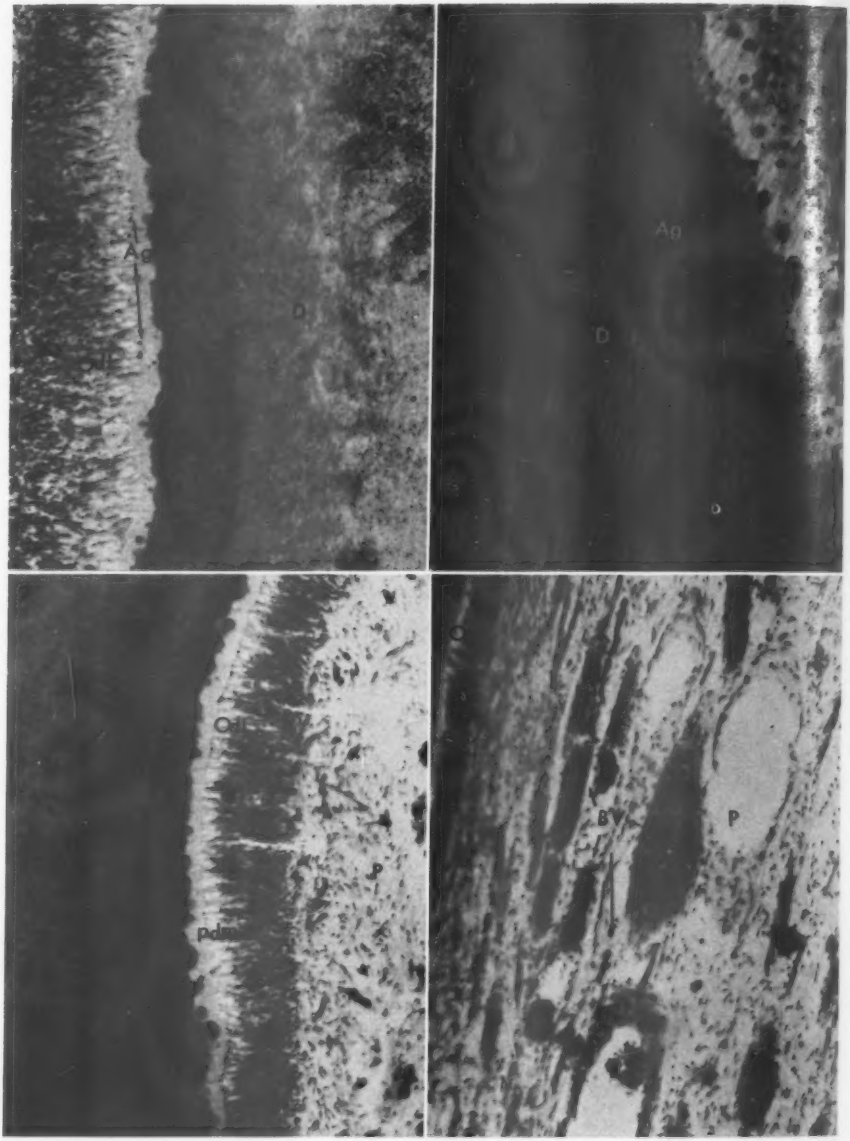

Fig. 5.—Silver nitrate penetration of dentine after application to a shallow cavity in the upper left third incisor of a dog. The animal was killed immediately afterwards. Note silver particles (*Ag*) in the dentine (*D*) and in the odontoblastic layer (*OdL*) of the pulp (*P*). (Magnification, ×100; reduced ⅔.)

Fig. 6.—Silver nitrate penetration of dentine and pulp after application to a deep cavity in the upper left second premolar of a dog. The animal was killed following the operative procedures. Silver particles (*Ag*) in large quantities have penetrated dentine (*D*) and pulp (*P*). (Magnification, ×450; reduced ⅔.)

Fig. 7.—Moderately deep cavity preparation of the lower left first molar of a dog. The animal was killed fourteen hours later. Edema is present in the odontoblastic layer (*OdL*), causing loss of the pulpodentinal membrane (*pdm*). Remainder of pulp (*P*) is normal. *D*, Dentine. (Magnification, ×100; reduced ⅔.)

Fig. 8.—Pulp (*P*) of upper left third incisor of a dog fourteen hours after preparation of a deep cavity. *OdL*, Odontoblastic layer. Blood vessels (*BV*) are hyperemic. (Magnification, ×100; reduced ⅔.)

Pressure: The effects of pressure were "isolated" by working on very shallow cavities (3.6 mm. or more of shielding dentine) whose preparation involved minimum trauma. Pressure exerted through such cavities was followed by the same kind of changes in the odontoblastic layer as those produced by the trauma of deep cavity preparation alone, namely, typical odontoblastic changes but no acute inflammation (Figs. 9 and 10). The deep pulp tissue, however, became quite hyperemic.

Silver nitrate: In ordinary cavity preparation, the addition of silver nitrate apparently added an extra increment of irritation, producing slightly greater inflammatory changes than would have been present if the only trauma had come from cutting the cavity (Fig. 11). In general, addition of one or more irritants to a shallow cavity preparation produced extra changes, so that the total effect was like that of deep cavity preparation.

Silver nitrate plus pressure plus injury from deep cavity preparation, in combination, caused the most severe changes in the pulp. The pulp was totally disrupted. No semblance of an organized odontoblastic layer remained. The layer was heavily infiltrated with polymorphonuclear leukocytes. Silver particles were found interspersed even among the odontoblasts on the other side. Apparently, pressure forced a deeper penetration of silver particles into the pulp than would have occurred otherwise.

Pulp exposure: A pulp exposure caused severe inflammatory changes in both the odontoblastic layer and the underlying pulp tissue (Fig. 12). The inflammation was acute, even if the cavity otherwise was very shallow. If the pulp was exposed in an otherwise shallow cavity and pressure was exerted, polymorphonuclear leukocytes heavily infiltrated the odontoblastic layer and were found interspersed throughout the entire pulp. An acute pulpitis was thus produced. Pressure such as that exerted in the making of full crown preparations or modeling compound impressions on teeth with exposed pulps would result in almost total destruction of the pulps by hemorrhage and edema.

Bacteria: If *S. faecalis* was placed on the dentine of teeth treated with silver nitrate, small round particles of bacteria size could be found within the pulp and the odontoblastic layer, but it was not possible to tell with certainty whether they were bacteria or particles of silver. If *S. faecalis* was placed on the dentine in either a shallow or a deep cavity and pressure was applied, a small number of bacteria could be seen in the odontoblastic layer. This confirmed our previous work with bacterial cultures which indicated that bacteria present on the dentine could be forced into the pulp by cavity preparation. If there was a pulp exposure and pressure was applied, the bacteria could be found even on the opposite wall of the odontoblastic layer and scattered throughout the pulp.

One Week After Treatment.—Observations on the dental pulps of the dog killed one week after treatment confirmed the conclusions drawn from the study of the dog killed after fourteen hours.

Cavity preparation: Again, the depth of the cavity was the controlling factor. If brain-heart infusion broth was applied to shallow cavities (1.2 mm.

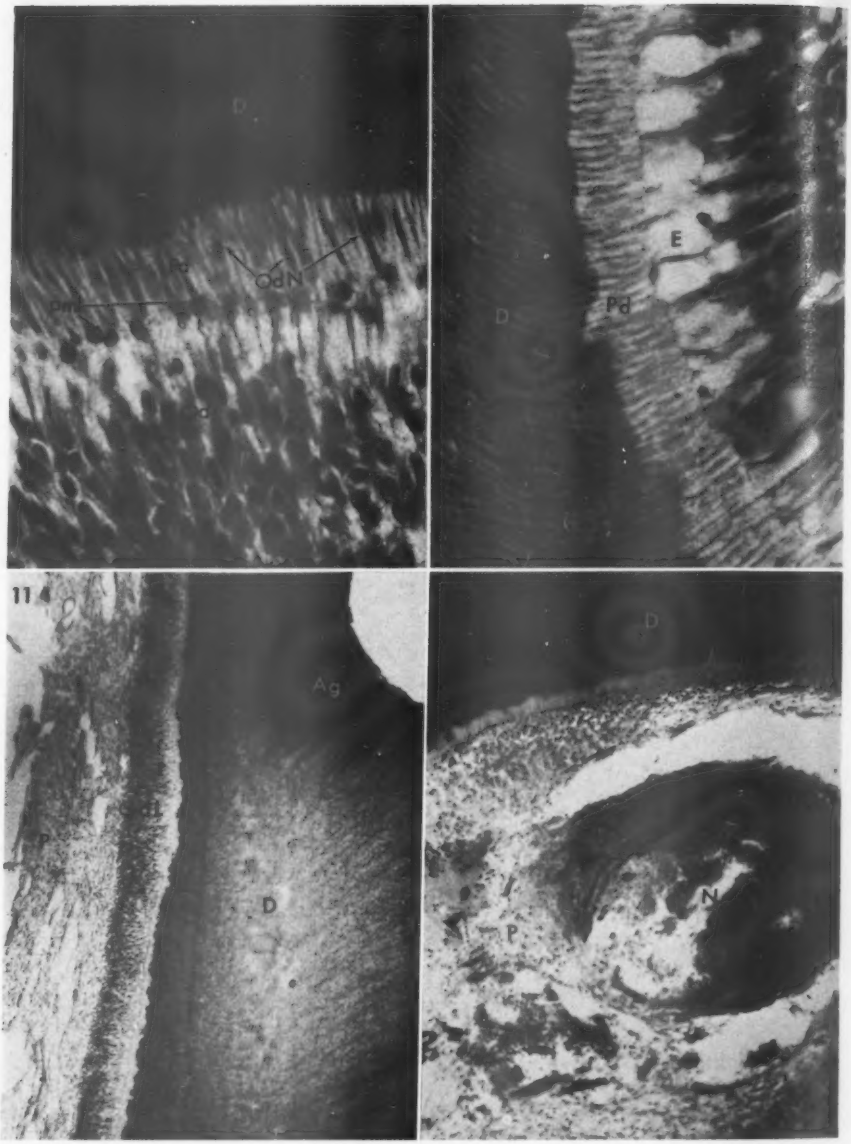

Fig. 9.—High-power magnification of odontoblastic layer (*OdL*) of pulp (*P*) of dog one day after treatment. Pressure had been applied to a moderately deep cavity. *D*, Dentine. Polymorphonuclear leukocytes (*Pml*) are seen at the pulpodentinal membrane. Odontoblastic nuclei (*OdN*) are displaced into the predentine (*Pd*). (Magnification, ×450; reduced 3/7.)

Fig. 10.—Odontoblastic layer (*OdL*) of pulp (*P*) of lower left third premolar of a dog. The cavity was shallow, and the animal was sacrificed one day later. *E*, Spaces in the odontoblastic layer caused by edema; *D*, dentine; *Pd*, predentine. (Magnification, ×450; reduced 3/7.)

Fig. 11.—Section of upper left third incisor of a dog. The cavity was treated with Howe's silver nitrate solution. The animal was killed one day later. *Ag*, Silver stain of dentine (*D*); *OdL*, odontoblastic layer; *P*, pulp. (Magnification, ×35; reduced 3/7.)

Fig. 12.—Pulp (*P*) of lower right fourth premolar of a dog one day after exposure and application of Howe's silver nitrate solution. Central pulp tissue is necrotic (*N*). *D*, Dentine. (Magnification, ×100; reduced 3/7.)

layer or more), pulp changes were minimal (Fig. 13). A pulp protected by a 2.4 mm. of dentine was normal except for disruption of the odontoblastic layer in one region and the presence of a few scattered red blood cells and macrophages in the pulp horn. In teeth with deep cavities an acute pulpitis developed; the odontoblastic layer was invaded by polymorphonuclear leukocytes, large numbers of odontoblastic nuclei were visible in the predentine, and the underlying pulp tissue was likewise invaded by polymorphonuclear leukocytes and macrophages (Fig. 14).

Pressure: Pressure applied to shallow cavities had no apparent effect on the pulp.

Silver nitrate or phenol, singly: In shallow cavities (3.0 mm.) application of silver nitrate or phenol produced very few changes (Fig. 15), but in a deep cavity (0.6 mm.) silver nitrate caused severe damage to the pulp (Fig. 16). The vessels in the deep pulp tissue were enlarged and contained an increased number of neutrophils. Thus, irritants applied to shallow cavities had little effect; when the same irritants were applied to deep cavities, the deleterious effects were compounded. On an exposed pulp, silver nitrate caused an acute total pulpitis.

Silver nitrate plus bacteria: In a tooth with a cavity of borderline depth (1.2 mm.), treated first with silver nitrate and then with bacteria, the odontoblastic layer and the deep pulp were invaded by polymorphonuclear leukocytes (Fig. 18). Bacteria and/or silver nitrate particles (it was difficult to tell which) were found in the deep pulp tissue. Similar treatment of deep cavities was followed by acute inflammation of the pulp and, in many regions, by necrosis. Macrophages, found in the deep pulp tissue, were loaded with silver particles or bacteria. Apically, bone resorption and an increased infiltration of polymorphonuclear leukocytes had occurred. Thus, the very beginning of an apical region of rarefaction could be seen.

Phenol plus bacteria: Following treatment of a relatively shallow cavity (2.4 mm.) with phenol and bacteria, the pulp was acutely inflamed (Fig. 17). Bacteria were found in the dentinal tubules and in the pulp. (It seems that phenol, far from making the dentine more resistant, actually opens the tubules for further penetration of bacteria.) The entire odontoblastic layer was destroyed. The nuclei were fragmented and lysed. There were small, diffuse hemorrhages scattered throughout the odontoblastic layer, even on the side opposite the cavity preparation. The odontoblastic layer was heavily infiltrated with polymorphonuclear leukocytes. In some instances the dentinal tubules of the predentine had been cleaved by the pressure of ingrowing polymorphonuclear leukocytes, debris, dead cells, and bacteria. Odontoblastic nuclei were displaced into some sections of the dentine.

Phenol plus bacteria plus pressure: When cavities were treated first with phenol, then with *S. faecalis,* and finally with pressure, bacteria could be detected within the deep pulp. Likewise, bacteria could be found in the deep pulp if they had been applied to the cavity before the phenol treatment, thus

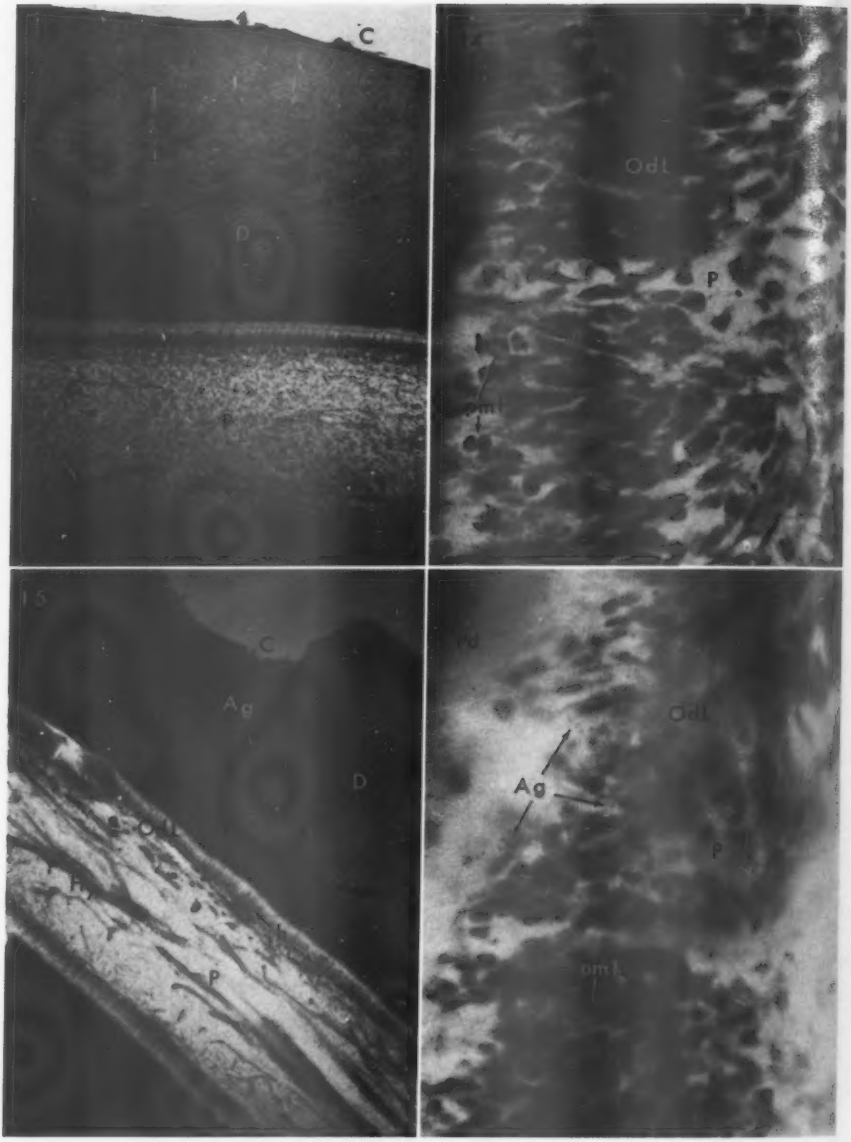

Fig. 13.—Lower left first molar of a monkey. The animal was killed one week after a shallow cavity (*C*) was prepared in the dentine (*D*). Odontoblastic layer (*OdL*) of pulp (*P*) appears normal. Magnification, ×35; reduced 3/7.)

Fig. 14.—Higher magnification of the odontoblastic layer (*OdL*) of the pulp (*P*) of an upper right first molar of a dog. A deep cavity had been prepared in the dentine (*D*). The animal was killed one week later. The odontoblastic layer is no longer palisaded and is infiltrated with polymorphonuclear leukocytes (*pml*). (Magnification, ×450; reduced 3/7.)

Fig. 15.—Treatment of a moderately deep cavity in the lower left first premolar of a monkey. The cavity (*C*) in the dentine (*D*) had been treated with Howe's silver nitrate solution one week earlier. Silver particles (*Ag*) are present in the dentine. The pulp (*P*) is hyperemic (*Hy*), and there are small hemorrhages (*h*) in the odontoblastic layer (*OdL*). (Magnification, ×35; reduced 3/7.)

Fig. 16.—High magnification of the odontoblastic layer (*OdL*) of the pulp (*P*) of the upper right third incisor of a dog. A deep cavity had been treated with Howe's silver nitrate solution. The animal was killed one week later. Silver particles (*Ag*) are interspersed in the pulp tissue. The odontoblastic layer (*OdL*) is disoriented and infiltrated with polymorphonuclear leukocytes (*pml*). (Magnification, ×450; reduced 3/7.)

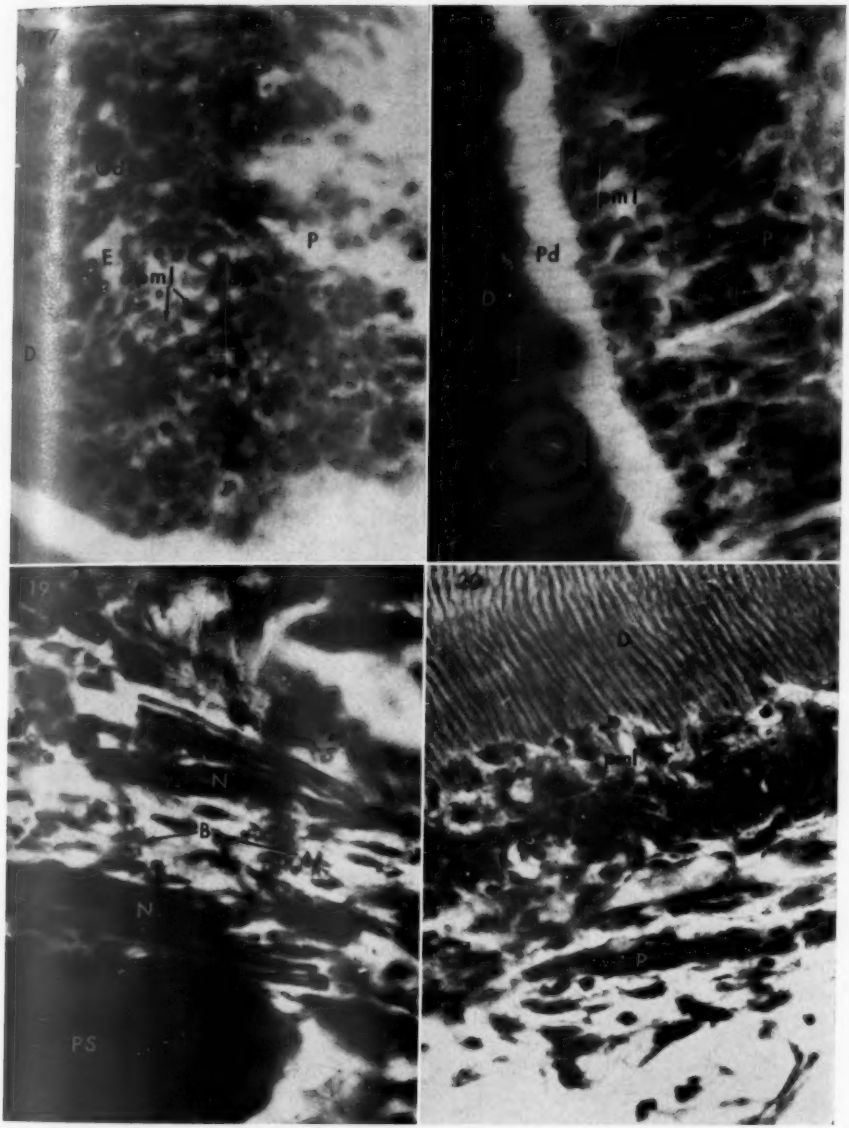

Fig. 17.—Section of lower right first molar of a dog. Phenol was applied to the base of a cavity and the animal was killed one week later. The odontoblastic layer (*OdL*) of the pulp (*P*) is heavily infiltrated with polymorphonuclear leukocytes (*pml*). The odontoblasts are destroyed by the edema (*E*). The predentine is missing. *D*, Dentine. (Magnification, ×450; reduced 3/7.)

Fig. 18.—Howe's silver nitrate solution and pressure were applied to the base of a cavity in the lower left canine of a dog. One week later the animal was sacrificed. The pulp (*P*) is inflamed. Polymorphonuclear leukocytes (*pml*) have displaced the odontoblasts. *Pd*, Predentine; *D*, dentine. (Magnification, ×450; reduced 3/7.)

Fig. 19.—A suspension of a twenty-four-hour culture of *Streptococcus faecalis* was placed on the base of a cavity for one minute. This was followed by the application of phenol and pressure. The animal was killed one week later. The bacteria (*B*) were found within the pulp (*P*), especially around nerves (*N*). *PS*, Pulp stone. (Magnification, ×450; reduced 3/7.)

Fig. 20.—A cavity was prepared in the dentine (D) of the lower right first molar of a dog. Phenol was then applied for one minute. One month later the animal was killed. The predentine is missing. The odontoblastic layer is disoriented and heavily infiltrated with inflammatory cells (*pml*). The remainder of the pulp (*P*) is edematous. (Magnification, ×450; reduced 3/7.)

again indicating that phenol does not render the dentine less permeable. Pressure presumably helped force the bacteria into the deep pulp, where they were present in great numbers. Inflammation, induced in the deep pulp by the phenol, apparently provided localizing sites for the attraction of bacteria (Fig. 19).

One Month After Treatment.—By the end of the month, to judge from the teeth of the dog killed at this time, the pulps had largely recovered from the effects of cavity preparation, pressure, and the application of silver nitrate or bacteria, but the response to phenol had not subsided.

Cavity preparation: All cavities prepared in this dog were shallow or of medium depth. Effects of deep cavity preparation in this experiment can only be estimated by equating them with effects of medium cavity preparation plus an added irritant.

At the end of one month, the acute response was no longer evident. Polymorphonuclear leukocytes, for the most part, were gone and had been replaced by a few lymphocytes scattered throughout the body of the pulp. Otherwise, the pulp was relatively normal.

Pressure: Where pressure had been applied to the moderately deep cavity, the predentine zone was narrower or completely absent in one region, indicating some local interference with the viability of the odontoblasts.

Bacteria: Bacteria could not be detected within the pulp following their application to a moderately deep cavity one month previously.

Silver nitrate: In the deep pulp tissue of a tooth with a silver-nitrate-treated cavity, lymphocytes and macrophages were discernible, but not in large numbers (Fig. 21). There also were some scattered erythrocytes and polymorphonuclear leukocytes, and the blood vessels were still enlarged. It appeared that there had been a total pulpitis, which was now tending to disappear. In some instances a few other changes were observed, such as a calciotraumatic response, reduction in the width of the predentine, and the presence of odontoblastic nuclei within the predentine, but otherwise the pulp was normal (Fig. 22). The walls of the blood vessels were stained brown by the silver nitrate.

Phenol: The effects of phenol were much more severe than the effects of silver nitrate. In very shallow cavities the pulp was relatively normal, there being a few scattered lymphocytes and erythrocytes within the body of the pulp. In slightly deeper cavities, pulp changes were marked. Central pulp tissue was intact, but moderately infiltrated with lymphocytes. Although the pulp probably would have recovered, it apparently had been acutely inflamed. In some regions the odontoblastic layer was reduced in width (Fig. 20).

When phenol was applied to an exposed pulp, the deep pulp tissue was still acutely inflamed one month later. The connective tissue showed evidence of fragmentation, and there was considerable edema. Polymorphonuclear leukocytes were present, as well as cells of the chronic inflammatory series. Thus, an acute pulpitis still persisted after a month.

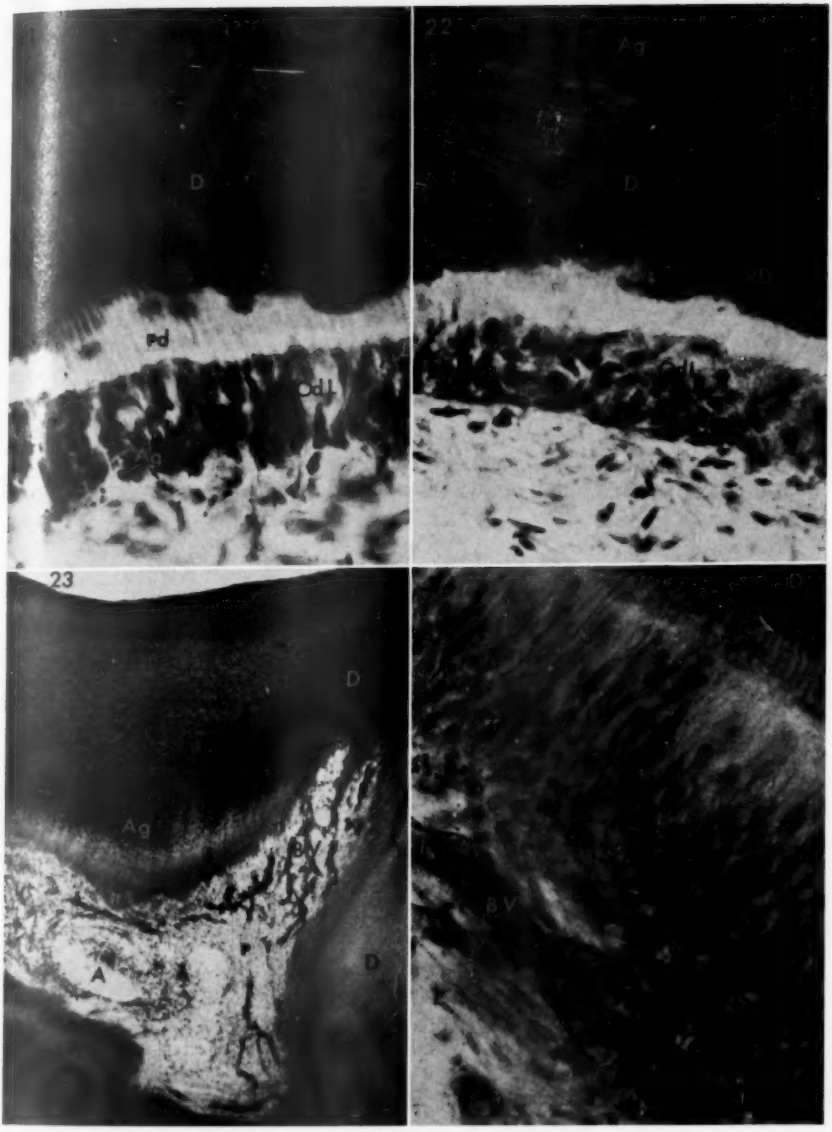

Fig. 21.—Silver nitrate was applied to a cavity on the upper right canine of a dog. The animal was killed one month later. Silver particles (*Ag*) have penetrated the pulp and are found interspersed in the odontoblastic layer (*OdL*). The pulp (*P*) is edematous. *Pd*, Predentine. (Magnification, ×450; reduced 3/7.)

Fig. 22.—Histologic appearance of upper left third premolar of dog one month after application of Howe's silver nitrate solution and pressure to dentine of prepared cavity. Silver particles (*Ag*) are present in dentine (*D*). Damaged odontoblasts (*OdL*) have elaborated reparative dentine (*RD*). (Magnification, ×450; reduced 3/7.)

Fig. 23.—Penetration of silver nitrate. Application of silver nitrate to dentine of upper right second premolar of dog. Silver particles (Ag) are present in heavy concentration in both dentine (*D*) and pulp (*P*). Blood vessels (*BV*) in pulp are stained black by silver nitrate. *A*, Abscess in control pulp. (Magnification, ×35; reduced 3/7.)

Fig. 24.—Higher magnification of blood vessel (*BV*) below odontoblastic layer (*OdL*) of pulp (*P*) showing silver stain of endothelial wall of blood vessel (*BV*). *D*, Dentine. (Magnification, ×450; reduced 3/7.)

Phenol plus bacteria: One month after application of bacteria to a phenol-treated cavity, changes in the pulp were still severe. In one region, the predentine was completely absent. Here the odontoblastic layer was disoriented. Polymorphonuclear leukocytes and lymphocytes prevailed. In one tooth, bacteria could be detected within the central pulp tissue.

Phenol plus bacteria plus pressure: If the bacteria were added to a phenol-treated cavity and then pressure was applied, the bacteria could be detected in the deep pulp tissue—often localized on or around nerve tissue.

A Note on Silver Nitrate Penetration.—Penetration of silver nitrate in dogs' teeth was along a conelike course, with the base of the cone toward the cavity preparation. The base of the cavity itself was deeply stained. Next to this deep stain there usually was a small zone with little silver penetration, although the dentine was stained brownish. There followed a dense brown-stained zone in which silver particles were interspersed. In teeth with deep cavities, the silver was found within the odontoblastic layer and within the pulp tissue (Fig. 23).

Nerves and blood vessels were also stained by silver, even the walls of blood vessels on the side of the pulp opposite the side where the cavity was cut (Fig. 24). In some instances, silver particles were even found within the fibers, blood vessels, and interstitial spaces of the periodontal membrane and within the marrow spaces of the bone.

CHANGES OBSERVED IN PULPS OF MONKEYS' TEETH

Monkeys were less satisfactory than dogs as experimental animals. Cavities which presumably had been drilled to a deep level, as judged by experience with dogs' teeth, turned out, in practically every instance, to be shallow (that is, a thick layer of dentine remained between the base of the cavity and the pulp). In the deepest preparations in the monkeys, 1.8 mm. of dentine remained; this thickness in the dog was usually sufficient to protect the pulp from injury. This problem might have been avoided if more meticulous attention had been given to the morphology of monkey teeth before the beginning of the experiment.

Another difficulty with monkeys' teeth, which applied in particular to evaluation of early changes in the pulp, was the morphology of the odontoblastic layer. The cells in this layer, the first to be affected by trauma during cavity preparation and treatment, were not consistently arrayed in palisade formation, even in the normal state. Although the palisade arrangement was found in many instances, there were sections of teeth in which the odontoblasts were flattened or completely absent under the roof of the pulp chamber and on the floor of the pulp chamber.

Also, microscopic examination was difficult because the specimens of monkeys' teeth had been embedded in celloidin, making it necessary to cut the sections relatively thick (minimum, about 12 microns). Although the celloidin method of embedding is advantageous in pulp studies, since it reduces the occurrence of shrinkage artifacts, our technology has been unable to overcome the hazard of thick sections.

Two Hours After Treatment.—Depth of cavity and application of pressure were factors affecting the pulps of the monkey killed two hours after treatment; the addition of silver nitrate or bacteria had relatively little effect. Bacteria could not be found in any part of the pulp, although it is conceivable that they were present but confused with silver particles. Had deeper cavities been available for study, possibly a reaction to silver nitrate and bacteria would have been observed.

In teeth with relatively deep cavities, polymorphonuclear leukocytes had already invaded the odontoblastic layer and were present throughout the body of the pulp. When pressure was applied to such a cavity (along with bacteria whose effect, if any, was probably small), a total pulpitis developed. Silver nitrate plus bacteria in a shallow cavity produced only a mild inflammatory reaction.

In the *dog* killed at a similar interval after treatment, there were no signs of inflammation. It would appear from the evidence at hand that inflammatory responses in dental pulps occur more quickly in monkeys than in dogs.

One Week After Treatment.—

Cavity preparation: In teeth with cavities prepared to shallow depths (dentine layer more than 1.8 mm. thick) with no additional irritant or with any one additional irritant, the pulp was normal. From a comparative study of teeth treated with various irritants through different thicknesses of dentine, it seemed evident that the extent of trauma to the pulp was related to the depth of the cavity.

Pressure: Significant changes in the pulps of teeth with relatively shallow cavities were observed only if the cavities were subjected to one of the following combinations of irritants: (1) phenol and pressure, (2) phenol, bacteria, and pressure, or (3) silver nitrate and pressure. Pressure was the common factor in these combinations and probably was a cause of changes in the pulp.

Bacteria: Bacteria were not detected in the pulp, even when applied to the deeper cavities.

Phenol: Phenol alone produced no changes in the deep pulp tissues. Application of phenol and pressure on a shallow cavity (2.1 mm. dentine layer) was followed by an intense calciotraumatic response. A large amount of predentine was observed, apparently laid down rapidly as a reaction to the irritation. The underlying pulp was hyperemic, and a few scattered polymorphonuclear leukocytes and macrophages were visible. After phenol, bacteria, and pressure had been applied to a dentine layer 2.4 mm. thick, a few scattered polymorphonuclear leukocytes and macrophages were observed; nuclei of odontoblasts were present in the predentine, and bacteria were scattered throughout the deep pulp tissue. It seems that in monkeys, as in dogs, phenol opens the tubules sufficiently to permit passage of bacteria.

Silver nitrate: Silver nitrate alone had no effect on the pulps of the monkey teeth studied.

In one tooth with a cavity cut to within 1.2 mm. of the pulp and treated with silver nitrate and bacteria, hemorrhages were observed all along the odontoblastic layer and in the deep pulp tissue, but the inflammatory reaction was not severe. The depth of the cut, rather than the silver nitrate, may have been the cause of the hemorrhages.

With silver nitrate and pressure on a dentine layer 1.8 mm. thick, blood vessels were ruptured in the odontoblastic layer and the deep pulp tissue. The remaining blood vessels were hyperemic. There were hemorrhages, even on the side of the odontoblastic layer opposite the cavity preparation. Silver particles were scattered throughout the pulp. Endothelial cells lining some of the vessels were stained black with silver nitrate.

DISCUSSION

Controls.—Although we studied the effects of pressure, drugs, and bacteria by comparing pulps of teeth subjected to these irritants with pulps of control teeth, we were unable to eliminate all variables. Thus, we could not completely control such variables as (1) differences in cavity depth, (2) inequalities of pressure transmitted to the dentine by the drill, (3) variations in the coolant effect of the water lubricant, and (4) differences in the kinds of teeth prepared. In studies of this type it is especially important that the teeth compared have cavities of the same depth, that is, that the pulps be shielded from the irritants by dentine layers of the same thickness. We were unable to accomplish this control.

Experimental Animals.—The use of monkeys for experiments on pulp reactions is not to be recommended. In addition to the technical problems described in the section on monkeys' pulp reactions, other objections are the expense of these animals, their proneness to respiratory ailments, and the difficulty of handling them.

Dogs are more satisfactory for studies of this kind, although care must be taken that the animals are of about the same age and size and that they are in good health.

Cavity Depth.—There is general agreement that the deeper the cut of the cavity, the more severe is the pulp damage. Our results confirm that deep cavity preparations made with steel instruments at 6,000 to 8,000 r.p.m. produce severe pulp damage. Relatively mild pulp changes, confined to the odontoblastic layer, are produced in shallow cavity preparations.

Pressure.—Pressure exerted on a relatively shallow cavity produces effects similar to those occurring after deep cavity preparation without added pressure. Pressure on deep cavity preparations results in severe damage to the pulp.

Drugs.—Silver nitrate or phenol applied to shallow cavities produces only minor damage to the pulp. This observation again emphasizes the shielding or protective effect of a thick layer of dentine. Application of these drugs to deep cavity preparations is followed by great pulp damage.

Pressure and Drugs in Combination.—If pressure and the other irritants are applied in combination, the inflammatory response is severe, the deep pulp tissue as well as the odontoblastic layer becomes involved, and the final result is likely to be a complete necrosis of the pulp.

Pulp Exposure, Drugs, and Pressure.—An exposure in itself produces severe inflammatory response within the pulp. If, in addition, drugs, bacteria, and pressure are applied, the pulp succumbs quickly and violently.

Penetration of Bacteria.—Bacteria can penetrate the dentine via the tubules and reach the deep pulp tissue, as can be demonstrated both by histologic examination and by the taking of cultures. Pressure on the base of the cavity forces the bacteria through the dentinal tubules. Application of phenol facilitates entrance of the bacteria by rendering the tubules more permeable. The permeability of the dentine of monkeys' teeth is different from that seen in dogs.

Course of Pulp Reactions.—Two hours after application of irritants, only the trauma of cavity preparation itself had any observable effect on the dental pulps of dogs, and this effect was mild. Fourteen hours after treatment, and also one week after treatment, the response of the pulps to the other irritants was also apparent. By the end of one month, the pulps had largely recovered from the effects of all the irritants tested with the exception of phenol. An inflammatory response was observed earlier in the monkey than in the dog (at the two-hour interval instead of the fourteen-hour interval), but the evidence was insufficient to justify a generalization about the relative rapidity of response in the two animals.

SUMMARY

Irritants were applied to prepared cavities in the teeth of dogs and monkeys, the animals were killed at intervals, and the dental pulps were examined for evidence of histologic change. The degree of damage to the pulp was judged by such criteria as nuclear and cytoplasmic changes in the odontoblasts, altered arrangements of the odontoblasts, disruption of the pulpodentinal membrane, vascular changes, changes in matrix formation and postoperative calcification, formation of granulation tissue, and necrosis.

The deeper the cavity cut, the greater the change observed in the pulp. If the layer of dentine between the base of the cavity was thick, it shielded the effect of irritants applied to the cavity. Next to the trauma of cavity cutting itself, the greatest damage to the pulp was caused by application of pressure. Silver nitrate or phenol caused severe damage if applied to deep cavities or if used in combination with other irritants. Bacteria *(Streptococcus faecalis)* placed on the base of the cavity could penetrate the dentine and reach the deep pulp, particularly if pressure was exerted or if the dentinal tubules were opened wider by application of phenol.

In the dog, only the reactions to the irritation of cavity cutting were apparent in pulps examined immediately after treatment, but the effects of the other irritants could be seen in specimens taken fourteen hours after treatment.

By the end of one month, the pulps had recovered, to a limited degree, from the effects of all the irritants tested with the exception of phenol. Inflammatory responses seemed to occur sooner in the monkey than in the dog. Studies of the results obtained at two-, three-, and six-month intervals will be reported in a future article.

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RESEARCH

IS THE CONDYLAR GROWTH CENTER RESPONSIVE TO ORTHODONTIC THERAPY?

An Experimental Study in Macaca mulatta

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RECENTLY histologic evidence has been presented to show that early orthopedic treatment of micrognathia induced corrective transformations of the joint structures, including a forward displacement of the glenoid fossa and a growth spurt of the mandibular ramus.[7] Reports of self-corrections of this condition,[25] however, leave some doubt as to whether the observed condylar response was a result of treatment or a sequela of an intrinsic growth tendency. Thus, the question of the responsiveness of condylar cartilage to mechanical stimuli is still to be answered.

The role of functional stresses in determining the form of bones or their morphogenesis has long been debated. Wolff's[38] law of transformation, as a generalization, relates the structure of a bone to the stresses acting upon it, while Roux's principle implies universally morphogenetic properties of functional stimuli.

The response of the craniofacial complex to muscular activation has been thoroughly investigated by Häupl.[19] He agrees with Weinmann and Sicher[37] that change of function in the young growing skeleton leads to changes in form and structure, whereas in old matured bones it induces predominantly structural transformation.

In the light of recent experiments, the sweeping generalizations of earlier authors regarding the importance of extrinsic factors in determining skeletal form are found to have limitations, particularly where cartilage tissue is concerned. Fell[15] concludes, from findings in tissue cultures, that "gross morphology of bone tissue depends much more upon environmental influences than does that of cartilage." When primordia of long bones were isolated in vitro, they acquired a fairly normal shape. The blastema of avian limbs even formed the rudiments of the articulations in the absence of musculature. In contrast to this

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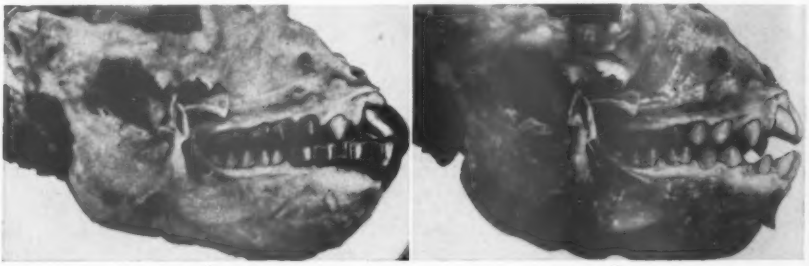
morphogenetic autonomy of cartilage, the shaping of bone tissue depends largely upon extrinsic factors. Ossifying avian and mammalian sterna exhibited, after prolonged culture, gradual loss of normal anatomic features.[12] In cultivated rudiments of long bones, tensile stresses were shown by Glücksmann[17] to accelerate endochondral ossification.

The exemption of cartilage tissue from Wolff's so-called law of transformation is further substantiated by the experiments of Strobino and associates.[33] After the epiphyseal plates in growing calves had been compressed by the application of pressures of 400 pounds per square inch for three months, absolutely no slowing of longitudinal growth was observed. This is in keeping with similar experiments of earlier observers.[14, 16] These results were also confirmed by the clinical experience reported by Blount and Zeier,[9] among others; growing epiphyseal plates in children can break steel staples that have been inserted for the purpose of retarding growth according to the method of Haas.[18]



A. *B.*

Fig. 1.—Head of experimental monkey 3, aged approximately 50 months at autopsy, before (*A*) and after (*B*) the bite planes were removed. Within a period of four and one-half months of treatment, an open-bite in a slightly forward mandibular position has developed.

In view of this biologic evidence, the orthodontist might easily be tempted to deduce that condylar cartilage also remains unresponsive to functional stimuli. The pitfalls of such reasoning by deduction in biology in general and in orthodontics in particular has been recognized.[3] Therefore, we decided to investigate the problem via the inductive experimental approach.

MATERIAL AND METHOD

The material consisted of a series of three female rhesus monkeys. Their age was between 44 and 50 months, as determined by the incipient stages of eruption of the permanent canines and first premolars.[4] Monkey 1 served as an untreated control. Monkeys 2 and 3 served as experimental animals. Plaster reproductions of both dental arches were mounted on an articulator in a forward mandibular position; then inclined planes, similar in effect to those used by Sleichter,[32] were modeled in wax and cast in metal (Fig. 1, *A*). The upper cast consisted of a splint around the four incisors, with an oblique plane in a downward and backward direction on the lingual side. The lower cast extended from the anterior teeth to the first permanent molars; the attached

short inclination plane which brought the mandible along the upper plane into a forward position. Six days after the appliance had been inserted with cement, both experimental monkeys had acquired this habitual forward position of the mandible during eating and playing.

From the beginning of the experiment all three monkeys were given periodic intravenous injections of alizarin red S.* Sagittal head films were taken at the beginning and at the end of the orthodontic treatment (Fig. 2).

Monkey 2 was killed after two and one-half months of the experiment; monkey 3 was killed and autopsied after four and one-half months of treatment (Fig. 1, *B*). Blocks of the left temporomandibular joint of each monkey were dissected and prepared for histologic analysis. Sections were cut in a sagittal direction at a thickness of 15 microns and stained either after the method of van Gieson or with hematoxylin and eosin stain.

The presence of alizarin red S proved to be detrimental to histodifferentiation. For this reason, midsagittal sections of the ramus of two additional control animals, aged 30 and 48 months, used in a previous study[2] were included.

The formalin-fixed right halves of the three mandibles were left undecalcified for gross examination of vital staining. After color photographs of the outer surface had been taken, these specimens were cut midsagittally, so that the coloring of the medullary bone and the invested tooth structures could be photographed. For the purpose of comparison, the tibial head and the humerus were examined in a similar way.

RESULTS

Roentgenographic Examination.—Tracings of the cephalograms of monkey 3 taken at the beginning and end of the experiment are shown in Fig. 3. The head of the condyle exhibits a fairly rounded shape; it rests upon the articular eminence. The distance between the mandibular neck and the postglenoid process is greater than normal (Fig. 3, *A*). Under the influence of the inserted appliance, forward displacement of the mandible has taken place.

The roentgenographic contours of the joint structures of the same experimental animal four and one-half months later are seen in Fig. 3, *B*. Superposition of this roentgenogram on the film taken in the initial stage (Fig. 3, *C*) reveals the sites of morphologic changes. The articular surface has become more oviform; the mandibular head now is dorsally more prominent with respect to the posterior border of the ramus than before treatment. The circumferences of the mandibular angle and the temporal parts of the mandibular articulation, however, coincide with those shown in the previous tracing.

The transposed cephalograms of monkey 2, before treatment and after two and one-half months of treatment, show less significant changes in the condyle.

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*As reported by Massler[21] in 1941, intraperitoneal injections of 2 per cent alizarin red S proved to be fatal in monkeys. Therefore, intraveous injections of a 1 per cent solution were tested first in guinea pigs. The procedure was then repeated in the monkeys, with 0.2 to 0.5 c.c. of the tested solution being injected. As soon as the red color disappeared from the urine, after eight to ten days, the injections were repeated. The monkeys tolerated this treatment well, probably because they were on a diet of coarse food enriched by eggs, fruits, and vitamins.

A. *B.*

Fig. 2.—Lateral cephalograms of normal control (*A*) and monkey 2 (*B*). Note forward displacement of the condyle under the influence of the inserted appliance. (Reduced ⅓.)

As a result of therapy, a roentgenographically visible transformation of the condyle has occurred.

Vital Staining.—Upon gross examination of the specimens, the normal control monkey and the experimental animals showed evidence of only patchy light staining at the external surfaces. In Fig. 4, *A* the lightly colored areas of monkey 3 are indicated by stippling. Cartilage and the anterior portion of the ramus are not stained at all.

Distinct differences are found when the midsagittal sections are compared. In the experimental specimens deeply stained areas are evident in the ramal core, extending from the third molar germ toward the condylar head (Fig. 4, *B*). Deeper coloration is also observed in the alveolar bone and in the medullary region of the mandibular angle.

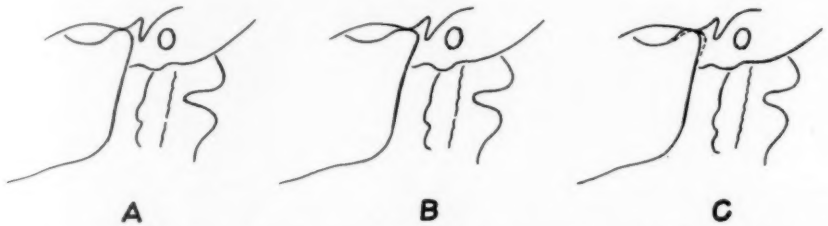


Fig. 3.—Tracings of roentgenograms of articular structures of monkey 3 at beginning of experiment (*A*) and after four and one-half months of treatment (*B*). *C*, Tracings *A* and *B* superposed. (Reduced 3/10.)

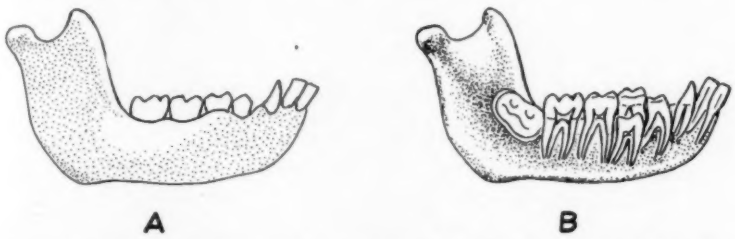


Fig. 4.—Vital staining in fixed, undecalcified mandible of monkey 3 is indicated by stippling at outer cortical bone surface (*A*) and in medullary core after dissection (*B*).

In the corresponding uncalcified sections of the normal control, as well as in the sections through the heads of the tibia of both normal and experimental animals, comparatively less deposition of alizarin is found.

The spongy bone of the ramus of the experimental animals appears to be in an active stage of structural transformation.

Histologic Analysis.—

Normal controls: A midsagittal section of the condyle of a 2½-year-old monkey is shown in Fig. 5. The cartilage shows its greatest width at the posterior half of the condyle, indicating endochondral growth activity in a

predominantly dorsal direction. From the convex arrangement of the chrondroblastic rows and the shortness of newly formed trabeculae, it can be concluded that little growth in height occurs. Brisk processes of modeling resorption along the anterior border and a broad osteoid seam at the posterior border point to an active growth movement of the mandible in a dorsal direction. Circumferential lamellae at the mandibular angle and base reveal simultaneous accretion at these sites (Fig. 6).

Fig. 5.

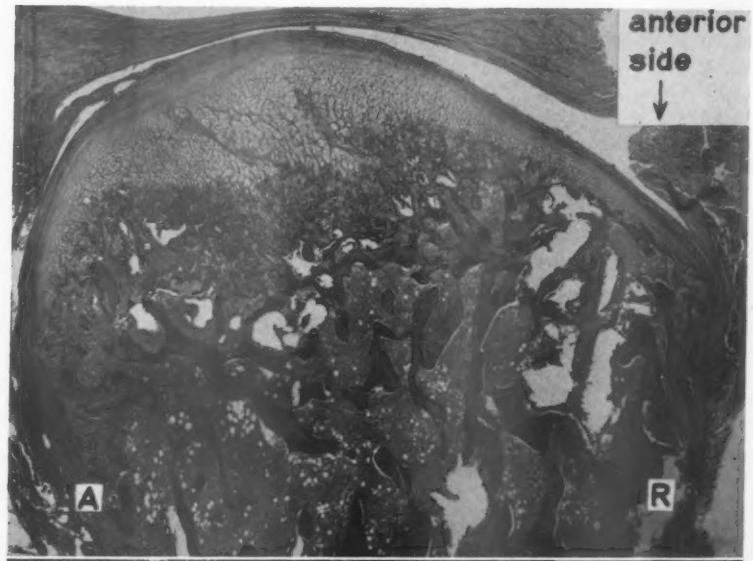


Fig. 6.

Fig. 5.—Midsagittal histologic section of condyle of normal monkey, aged 30 months, shows greatest cartilage width in the posterior region. Correlated processes of modeling resorption (*R*) at the anterior border and trabecular apposition (*A*) at the posterior border bring about a growth movement of the ramus in a dorsal direction. (Hematoxylin and eosin stain. Magnification, ×10; reduced ⅙.)

Fig. 6.—Surface of the gonial angle and lower mandibular border give evidence of periosteal accretion. (Hematoxylin and eosin stain. Magnification, ×10; reduced ⅙.)

In a specimen aged 4 years, which corresponds with the age of the experimental animals at autopsy, qualitatively the same growth processes are evident (Fig. 7). The rate of vertical growth, however, is reduced still more as judged from the decreased width of the condylar cartilage and the coarseness of the adjacent trabeculae. Active chondrogenesis still proceeds at the distal portion, directing a growth movement of the mandible in an almost exclusively posterior direction. The correlated processes of apposition at the posterior border and resorption at the anterior surface proceed at a steady rate.

Fig. 7.—The midsagittal section of upper mandibular portion of a 48-month-old monkey shows decreased width of cartilage. Endochondral ossification proceeds at a decreased rate. Note osteoid seam (*A*) at posterior border and modeling resorption (*R*) at anterior surface. (Hematoxylin and eosin stain. Magnification, ×6; reduced ⅙.)

Fig. 8 shows the joint structure of the normal control monkey. The condyle rests upon the anterior slope of the glenoid fossa. The periosteal surface of this temporal bone portion displays osteogenic inactivity, while the spongy inner portion undergoes some structural transformation (Fig. 9).

The developmental stage of the condylar head coincides with that depicted in Fig. 7; it exhibits moderate endochondral activity at the posterior portion of the condylar cartilage and relative rest at the anterior portion.

Fig. 8.

Fig. 9.

Fig. 8.—The sagittal section of joint structures of control monkey 1 shows developmental stage identical to that seen in Fig. 7. The condylar head rests on the articular disc at the anterior slope of the fossa.

(In Figs. 8 to 14, vital staining had unfavorable effects on histodifferentiation.)

Fig. 9.—The periosteum of the joint structures of the temporal bone gives evidence of an aplastic state. (Hematoxylin and eosin stain. Magnification, ×10; reduced ¼.)

Fig. 10.

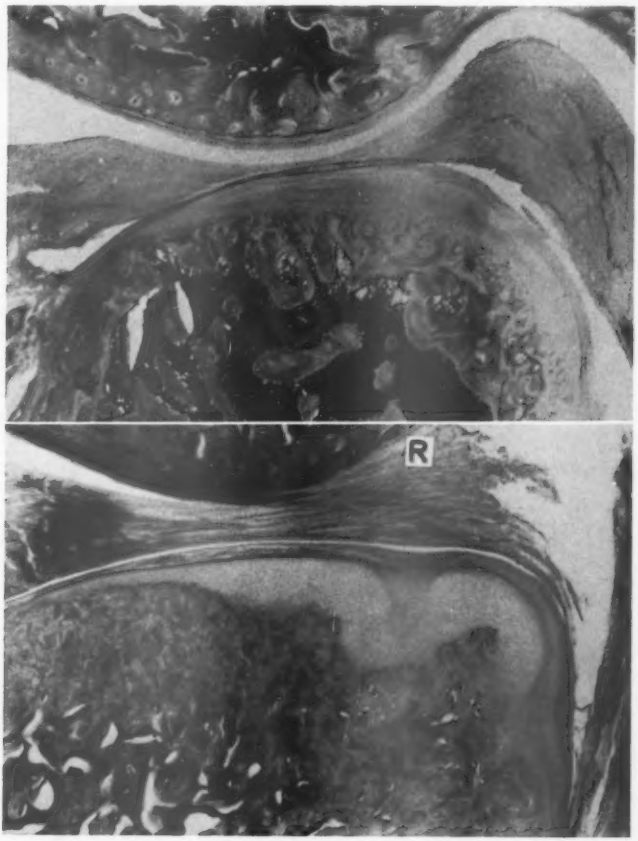


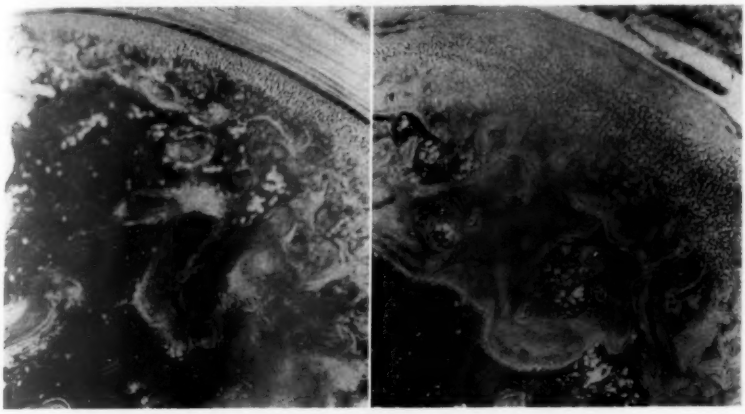
Fig. 11.

Fig. 10.—A sagittal section of the joint structures of experimental monkey 2 following two and one-half months of treatment. Note increased size of condylar head resting upon articular eminence.

Fig. 11.—The condylar head of monkey 3 following four and one-half months of experiment exhibits a prolonged, bilobed shape. Note resorption processes (*R*) in anterior portion of glenoid fossa.

Experimental animals: The most obvious changes noticed in the midsagittal joint sections of experimental monkeys 2 and 3, as presented in Figs. 10 and 11, concern the shape of the condylar head and the width of the cartilage.

Monkey 2, after two and one-half months of orthodontic treatment, shows an over-all increase in size of the condyle as the result of accretion at the upper and posterior sides and a slowed process of modeling resorption at the anterior border. The cartilage layer is twice as wide as that of the normal control. At a



A. *B.*

Fig. 12.—Posterior regions of condylar cartilage of normal control monkey 1 (*A*) and experimental monkey 2 of similar age (*B*). The growth response of the endochondral apparatus of the condyle to mechanical stimuli is obvious.

higher magnification, it can be seen that both chondrogenesis and osteogenesis are highly active. As in the normal control, the center of this activity is found in the posterior cartilage region; its greater width and its extension toward the collum region (Fig. 12, *B*) are indicative of increased growth activity at this condylar portion. The anterior border of the neck gives little evidence of modeling resorption.

More significant processes of modeling resorption are taking place at the surface of the articular eminence upon which rests the mesially displaced mandible (Fig. 13). Anteriorly, some apposition proceeds. The bony surface of the fossa is aplastic.

In monkey 3, after four and one-half months of orthodontic treatment, all these phenomena are accentuated. The condylar head has assumed a prolonged bilobed shape; chondrogenetic and osteogenetic processes at the posterior portion still are very active.

The joint structures of the temporal bone show the result of some morphologic transformation. The articular eminence exhibits several accretion lines, while the anterior portion of the fossa presents some deep osteoclastic lacunae. The extent of this transformation remains, however, at a microscopic level (Fig. 14).

The condylar cartilage, with its endochondral growth apparatus, was without doubt the tissue that responded most actively to the orthopedic therapy. Relatively little response was found in the joint structures of the temporal bone.

Fig. 13.

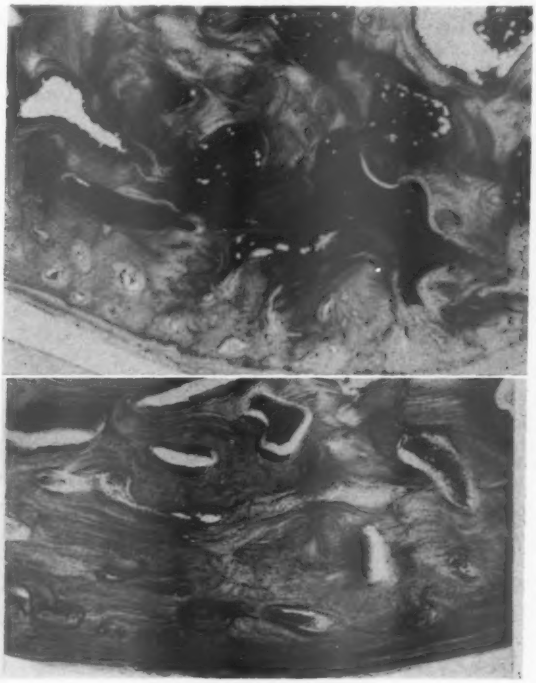


Fig. 14.

Fig. 13.—The synovial surface of the articular eminence of monkey 2 shows evidence of active processes of modeling resorption.

Fig. 14.—The articular eminence of monkey 3 shows lamellar apposition based on the resting line of former resorption.

DISCUSSION

Growth response of condylar cartilage and temporal joint structures to orthodontic therapy was first reported by Breitner,[10] who had made histologic observations in experimental monkeys. Ohta,[23] Häupl and Psansky,[19] Hoffer and Colico,[20] and Colico,[13] in similar laboratory experiments, showed changes in the condyles. Hoffer, Vogel and Pignatelli[36] demonstrated, by histochemical methods, that orthodontic appliance therapy engendered increased chondrogenic activity. Only recently there was presented histologic evidence that a transformation of the articular fossa and a growth spurt in the condylar heads occurred in a human infant treated for Pierre Robin's syndrome,[7] but it was not determined whether this phenomenon was the result of therapy or an innate tendency.

Both experimental monkeys used in the present study showed obvious changes in the gross morphologic and roentgenographic appearance of the condylar head. Its structural arrangement indicated increased cartilage proliferation in a predominantly backward direction; endochondral ossification was most active in the posterior portion. Since modeling resorption at the anterior portion lagged behind proliferation at the posterior portion, the condyles assumed a bilobed shape. These growth processes resulted, as best seen from the roentgenograms, in a bending of the condyles toward the fossa as if they were returning to the pretreatment position.

Thus, concrete evidence has been obtained to show that *the condylar growth center responds to functional therapy.* This fact deserves to be evaluated both from the biologic aspect and from the standpoint of its implication to orthodontic therapy.

Biologic Consequences.—The growth cartilage of the mandible evidently reacts differently to mechanical stimuli than do the epiphyses of long bones. This peculiar behavior is accompanied by differences in development, histologic structure, activity of endochondral ossification, and hormonal control.

Development: While all epiphyseal plates of long bones are derivatives of the primordial cartilage skeleton, the condylar cartilage is a so-called secondary cartilage. Symons[34] has shown that it originates distant to Meckel's cartilage in close relationship with the lateral pterygoid muscle. At about the fourth or fifth fetal month a cartilaginous cap differentiates above the dorsal end of the primitive mandible. Little is known concerning the onset of endochondral activity and the fusion of this cartilage bone with the membrane bone of the mandible.

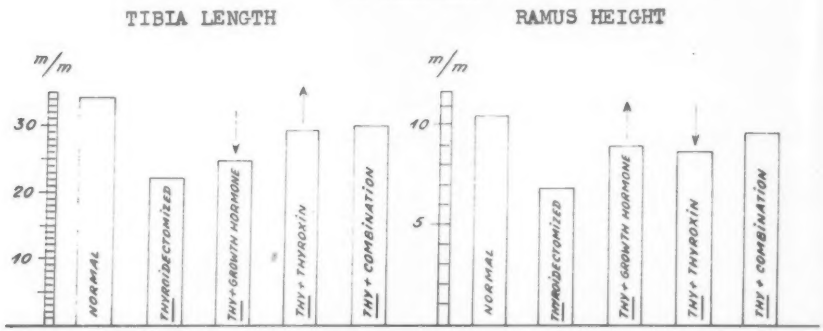
Histologic structure: The histologic structure of condylar cartilage is different from that of articular and epiphyseal cartilages.[37] Although similarly composed of hyaline cartilage, condylar cartilage is covered by perichondrium. From this connective tissue a system of collagen fibrils extends, in arch form, into the cores of the cartilaginous ground substance.

The chondrocytes originate in the perichondrium and are marshaled in radial rows indicating their direction of proliferation. While epiphyseal plates grow interstitially, condylar cartilage accrues by peripheral apposition.

Endochondral ossification: Differential cartilage proliferation is conducive to both the maintenance of the rounded cylindrical shape of the condyles and the backward—outward—upward development of the mandibular ramus.[5] The most active endochondral ossification is normally found in the deep layers of the lateroposterior cartilage. In contrast to other cartilage bones, no secondary ossification centers are formed. Maturation never occurs; cartilage persists throughout life; it is never completely eroded or sealed off, as are the epiphyseal plates. Although major growth of the human mandible ceases at about the age of 18 to 20 years, it can be resumed under pathologic conditions[31] at any later date.

Hormonal control: Endocrine experiments in rats have revealed amazing differences in the hormonal control of growth activity of the epiphyseal plates and the condylar heads. Following thyroidectomy, growth hormone elicited a greater response in the condyles than in long bones; these responded better to thyroxin (Table I).[6] Becks and associates[8] noticed that following hypophysectomy, combined therapy with growth hormone and thyroxin had an antagonistic effect on the condyles while in the same animals this same treatment produced optimal synergetic effects in the long bones.

TABLE I. DIFFERENT EFFECTS OF ENDOCRINE FACTORS IN THE CONDYLES AND TIBIAL EPIPHYSES OF SAME RATS



(From Baume, Becks, and Evans: *Am. J. Orthodontics* 39: 623, 1953.)

The sum of these biologic observations points to the fact that the mandible is originally a membrane bone; its cartilage is secondary in terms of both chronologic development and biologic reaction. Condylar cartilage, however, is essential for mandibular development, as best shown by pathologic conditions; disturbance in cartilage growth engenders the syndrome of micrognathia, receding chin, and impaction of permanent lower molars.[35]

The hyaline cartilage at the head of the mandible therefore holds a unique position; the orthodontist and the oral surgeon must learn to take advantage of it.

Orthodontic Consequences.—The biologic fact that condylar growth may be directed and stimulated by orthodontic therapy is of paramount interest to the dentist and the patient.

Andresen and Häupl[1] have based their entire school of "functional jaw orthopedics" upon this philosophy. Moore,[22] Oliver,[24] Ricketts,[26-28] Sleichter,[32] Salzmann,[29, 30] and Wylie[39, 40] have critically evaluated a clinical approach along this line. Most of these authors are rather reluctant to express an opinion, on the basis of roentgenographic analysis of treated cases, as to whether or not orthodontic therapy stimulates mandibular growth. They refer the solution of the problem to the field of experimental biology. The experts of a recent workshop on roentgenographic cephalometrics also arrived at the conclusion that, in

view of the lack of absolutely stable points of reference, growth sites are inscrutable to roentgenocephalometric analysis. Meaningful experiments should lead to more conclusive evidence.[30]

Some of the pertinent data concerning the histologic effects of experimental mandibular protraction are compiled in Table II. They suggest the following tentative conclusions:

1. The younger the subject, the greater and faster will be the induced growth response of the condyles and the joint structures of the temporal bone.

2. Transformation of the glenoid fossa depends upon a stable forward positioning of the mandible during an adequate period of time.

3. Stable forward positioning of the mandible engenders traumatic joint lesions in adolescents.

4. Activator bite planes consistently stimulate condylar growth, never harming but not necessarily transforming the joint structures of the temporal bone.

It is up to the orthodontist to test these experimental suggestions with conforming appliance therapy in well-analyzed cases. In so doing, he will enter the ever-expanding circle which relates basic research to clinical progress.

SUMMARY

A review of the recent literature indicates that, contrary to Wolff's law and Roux's principle, epiphyseal cartilage plates remain highly unresponsive to mechanical stimuli. A controlled experiment in three rhesus monkeys, aged 44 to 50 months, was designed to assess condylar response to orthopedic stimulation. Roentgenographic, vital-staining, and histologic analyses of the temporomandibular articulations after treatment periods of two and one-half and four and one-half months, respectively, yielded the following results:

1. The condylar cartilage with its endochondral growth apparatus responded most actively to functional therapy. Upon treatment, the condylar head assumed a prolonged, bilobed shape as part of a growth response that tended to compensate for the induced mandibular displacement.

2. Transformations of the joint structures of the temporal bone remained at a microscopic level. Comparison with experimental results so far published (Table II) suggests that this was due to the advanced age of the animals and the shortness of the experiment.

The unique properties of condylar cartilage among the endochondral growth apparatus were evaluated both from the biologic aspect and from the standpoint of its impact on orthodontic therapy.

TABLE II. COMPILATION OF DATA ON EXPERIMENTAL TRANSFORMATION OF TEMPOROMANDIBULAR JOINT

AUTHOR	YEAR	SUBJECT	AGE* (YEARS)	APPLIANCE	DURATION (WEEKS)	MANDIBULAR CARTILAGE	TEMPORAL BONE		
							ARTICULAR EMINENCE	GLENOID FOSSA	POSTGLENOID PROCESS
(1) Breitner	1930	Macaca	9	Fixed appliance with intermaxillary elastics	12	Marked growth, condyle enlarged	Marked apposition	Marked resorption	Bone formation
(2)		Macaca	4½	Jumping the bite, fixed	6½	Marked growth, condyle enlarged	Marked apposition	Marked resorption	Trabecular apposition
Häupl and Psansky	1939	Baboon	20	Activator bite plane daily 2 hours intermittently	11	Slight proliferation	Slight apposition	No resorption	Slight apposition
(1) Hoffer and Colico	1958	Macaca	14	Intermaxillary elastics on maxillary bite plane daily 3 hours intermittently	2	Slight proliferation	Structural transformation	Some resorption	Proliferation of connective tissue
(2)		Macaca	10	Activator intermittently 4 hours daily	4	Distinct proliferation	No transformation	—	—
Colico	1958	Macaca	19	Fixed bite jumping	20	Traumatization of fibrocartilage	Severe traumatic resorption	—	—
Baume, Häupl, and Stellmach	1959	Human	½	Intermittent protraction by weight	16	Over-all growth spurt	Apposition	Modeling resorption	Rapid bone formation
(1) Baume and Derichsweiler	1960	Macaca	11	Mandibular forward displacement with fixed inclination planes	10	Marked distal apposition	Resorption	Some apposition	No response
(2)		Macaca	14		10	Enlarged condyle	Reparatory apposition	Resorption	No response

*Approximately corresponding to human age according to dental development.[2]

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Section by the
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BRANCHIAL CLEFT CYST

Report of a Case

Matthew D. Branche, Captain, MC, USA, and
Jack Traiger, Captain, DC, USA

ALTHOUGH relatively common in children, branchial cleft cysts are seldom found in adults. Usually no problem is encountered in their diagnosis.

It is not difficult to differentiate a branchial cleft cyst from a more common lesion, such as an inflammatory lymph node, a salivary gland tumor, a lipoma, a carotid body tumor, and primary mandibular disease, if one suspects the presence of this entity. Knowledge of its mode of formation in the site of presentation, with its fluctuant nature and infrequent ease of transillumination, is indeed helpful to one considering this diagnosis.

Although much has been presented in the literature regarding this cyst's mode of development, diagnostic aids, and signs, we are presenting the following case as a relatively unusual finding in an adult male patient.

CASE REPORT

A. B., a 21-year-old white man, was admitted to the hospital on June 17, 1960, with a chief complaint of a lump of three months' duration on the left side of the neck. The patient had enjoyed excellent health until three months earlier when he noted the development of a small acorn-sized mass, approximately 2.5 by 2.5 cm. in diameter, at the angle of the mandible on the left side.[1] The patient denied a previous history of upper respiratory infection, cough, or infections about the teeth, paranasal sinuses, ears, or scalp. During the ensuing two and one-half months he noted progressive enlargement of the glands, and at times he observed a scratchy sensation in the back of the throat on the left side and was able to manipulate the tumor. He had no difficulty in swallowing. There had, however, been no drainage intraorally or from the mass externally. Approximately two months and three weeks prior to the present admission, he was hospitalized at Munchweiler United States Army Hospital in Germany for four days for preliminary studies and evaluation of the left neck mass. At that time x-ray studies of the lung and soft-tissue studies of the neck were essentially within normal limits.

From the Oral Surgery Section, Post Dental Clinic, Fort Jay, Governors Island, New York, New York.

Skin tests, including purified protein derivatives, histoplasmosis, and coccodio were all negative. Because the patient's separation date was several days away from his hospitalization in Germany, it was decided that he should be transferred to the Zone of the Interior for further treatment and evaluation, whereupon he was transferred to the United States Army Hospital at Fort Jay after a preliminary work-up at Fort Hamilton United States Army Dispensary.

The patient's past history was essentially noncontributory. There was no family history allergies, carcinoma, kidney disease, tuberculosis, mental illness, or bleeding tendencies. There had been no history of previous cervical masses in any members of the patient's family.

Physical Examination.—The patient was a well-developed, well-nourished white man in no acute distress. Examination of the head and neck revealed an egg-shaped mass, approximately 8 cm. long and 6 cm. wide, occupying the entire fossa below the left mandible (Figs. 1 and 2). The anterior extension reached as far anteriorly as the submental foramen and as far posteriorly as the mastoid process. The mass was not freely movable at its undersurface, but the skin and subcutaneous tissue over the anterior surface of the mass were freely movable. There were no points of drainage or adherence on the anterior surface. A sensation of fluctuance could be noted over the mass. Some tenderness was encountered on manipulation of the mass, at which time a scratching sensation in the back of the throat was experienced by the patient. No other cervical glands were palpable. Both supraclavicular regions were negative for glandular enlargement, and no spasm or tenderness was noted over either sternocleidomastoid muscle. The thyroid gland was normal in size; it moved when the patient swallowed, and it showed no evidence of nodularity. Examination of the throat revealed minimal mucous membrane injection; tonsils were absent, and there was no evidence or history of drainage in the region of the posterior tonsillar pillar on the left side. Transillumination of the fluctuant mass was not possible, probably because of the overlying platysma muscle.

Eye, ear, and nose examinations were normal. The scalp was negative. The chest revealed normal expansion, with good breast sounds and no evidence of diaphragmatic limitation. Heart examination revealed the point of maximum impulse at the fifth intercostal space along the midclavicular line. There was a regular sinus rhythm, and no murmurs were noted. The pulse rate was 72. The abdominal examination was essentially normal. There were no masses, hernias, hepatosplenomegaly, or areas of tenderness.

Rectal examination was within normal limits, showing good sphincter tone and no evidence of prostatic enlargement. The external genitals were essentially normal. The extremities revealed good muscle tone, normal arterial pulsations throughout, and no areas of atrophy or rashes.

Laboratory and X-ray Data.—Urinalysis revealed a yellow clear color, an acid reaction, a specific gravity of 1.023, and negative albumin and sugar. Microscopic examination showed only a few mucous threads. The white blood count was 7,400, with 73 per cent neutrophils and 7 per cent lymphocytes. Hemoglobin was 14.4 grams, and hematocrit was 40 per cent. Culture and sensitivity of yellow turgid fluid removed from the excised cyst revealed no growth after forty-eight hours of aerobic and anaerobic cultures. Chest examination on June 20, 1960, was essentially normal.

Hospital Course and Treatment.—The patient was taken to the operating room on June 21, 1960. After induction of general anesthesia with ether, nitrous oxide, and oxygen by way of an endotracheal tube, the left neck cyst was excised through an inframandibular incision (Fig. 3). The cyst, located below the sternocleidomastoid muscle, presented a thickened capsule with evidence of old inflammatory reaction and appeared to point posteriorly in the region of the bifurcation of the common carotids, as digastric muscle passed over this area. No internal cordlike structure was discernible, and pressure from the posterior tonsillar pillar toward the outside did not help in delineating any such fistulous tract. The defect below the sternocleidomastoid muscle was drained during the operation, and the posterior course was essentially benign. The drain was removed on the third day and all sutures were out by the fourth day. The patient tolerated the procedure well and was discharged to duty on June 27, 1960.

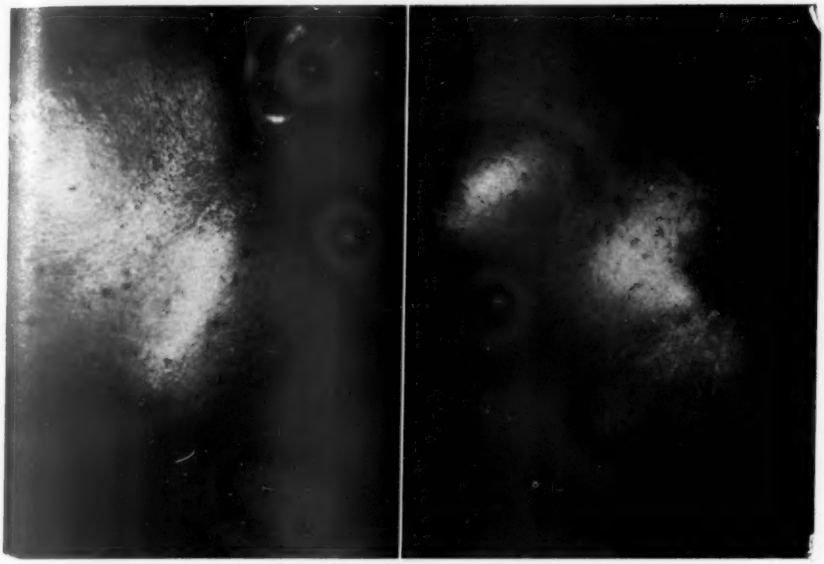

Fig. 1. Fig. 2.

Figs. 1 and 2.—Preoperative views of branchial cleft cyst.

Fig. 3.—Cystic structure being enucleated.

Pathologist's Report.—

Gross: The specimen consisted of a collapsed, previously opened cystic structure which measured 3.5 cm. in diameter. The wall was composed of firm brownish white tissue, and the cyst was lined with soft brownish material (Fig. 4).

Microscopic: Examination revealed the cystic structure to be lined in part by stratified squamous epithelium and in part by granulation tissue which was densely infiltrated by chronic inflammatory cells. The surrounding tissues were also densely infiltrated by chronic inflammatory cells.

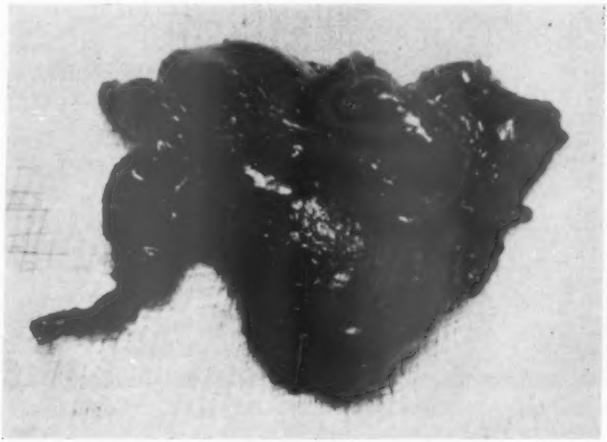

Fig. 4.—Branchial cleft cyst, surgical specimen removed.

Diagnosis: Wall of cyst revealing chronic inflammatory changes consistent with branchial cleft cyst[2] (Figs. 5 and 6).

DISCUSSION

A branchial cleft cyst is manifest clinically as a painless, fluctuant swelling, either on the lateral aspect of the neck or in the floor of the mouth. It is never in the midline. This developmental anomaly originates from epithelium that is entrapped between branchial arches. The branchial clefts are lined by ectodermal epithelium, and the pharyngeal pouches by endodermal epithelium. Therefore, it is possible, depending on which cells are entrapped, that these cysts may be lined by stratified squamous epithelium which originally was destined to become skin, by stratified squamous epithelium which would have become mucous membrane, or by pseudostratified ciliated columnar epithelium.

In the course of development of the neck, the second branchial arch or bar outgrows the rest of the arches in a caudal direction and overlaps them. This makes a recess on the side of the embryonic neck which is lined by epithelium and is called the lateral cervical sinus. Because of this formation, the epithelium from the second branchial cleft is entrapped more often than the epithelium from the other clefts.

Fig. 5.

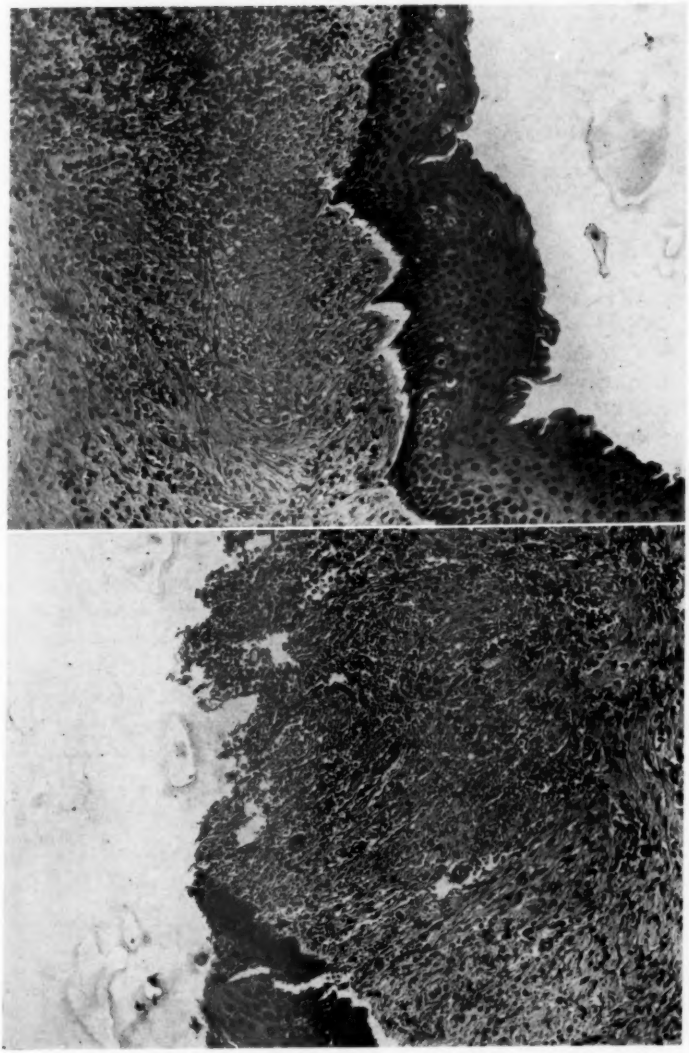

Fig. 6.

Fig. 5.—Histopathology of branchial cleft cyst.
Fig. 6.—Histopathology of branchial cleft cyst.

Branchial cleft cysts derived from the region in which faucial tonsils are developed (second pharyngeal pouch) often have lymphoid tissue in their walls. Sometimes these are designated as tonsillocysts because of their resemblance to dilated tonsillar crypts.[3]

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THE EFFECTS OF OSSEOUS IMPLANT MATERIALS ON REGENERATION OF ALVEOLAR CORTEX

Philip J. Boyne, Commander (DC) USN, Harvey W. Lyon, Captain (DC) USN, and Clarence W. Miller, Biologist, Bethesda, Md.

As a test site for bone implant investigation, the postextraction alveolus in man is influenced by a wide range of variable factors[1, 2] which alter the tissue repsonse and the chronological healing of the bony defect. It was felt, therefore, that periapical bone defects following root canal therapy and apical curettage offered a more realistic and more controllable test site for the study of the oral tissue response to osseous implant materials. In order to obtain some indication of the chronology of normal uncomplicated healing of human periapical bony defects, as well as the effect of osseous implant materials on the healing processes, we selected nine clinical adult patients who had similar multiple areas of periapical radiolucency involving anterior teeth. Regeneration of previously destroyed labial cortex was used as a criterion in evaluating the degree of osseous healing in this study, because of the ease with which the labial alveolar bone may be observed through postoperative re-exposure. Since the aim of surgical treatment is usually considered to be the restoration of the injured part to pre-existing morphology and function, the re-formation of destroyed labial bone cortex could be accepted as an indication of an advanced stage of osseous healing.[3]

MATERIALS AND METHODS

Following one-stage root canal therapy and periapical curettage, the area of labial plate destruction was measured. The diameter of lost labial cortex in these cases varied in size from 5 to 12 mm. One or more of the defects in each patient was implanted with an osseous material. No implant material was placed in the remaining periapical defect which served as a control. Three types of osseous implants were used in this study: (1) boiled, defatted bovine bone prepared by boiling the specimen in water for eighteen hours and extracting with ether for a period of three hours; (2) ethylenediamine-treated

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The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

bovine bone;[4] and (3) freeze-dried homogenous osseous tissue (obtained from the Tissue Bank of the Naval Medical School, National Naval Medical Center, Bethesda, Maryland). Ethylenediamine-treated bone and chemically boiled, defatted bone were of both cancellous and cortical types, having a particle size of 10/20 (U. S. Standard) mesh. The freeze-dried homogenous bone was also composed of both cortical and spongy types of approximately 10/20 mesh. In all cases, the bony destruction of the periapical defects did not involve periodontal pockets or sulci. Thus, the added variable of periodontal healing[3] was avoided. In all cases, the palatal or lingual bony cortex remained intact after curettage. Therefore, the healing of the periapical area in each case involved the filling of an intrabony defect and the restoration of *one* bony cortex.

Teeth that exhibited acute or subacute clinical exacerbation of a periapical inflammation were not operated upon until all acute symptoms had subsided. Patients with microscopically dissimilar periapical lesions were not considered in this series. The periapical defects compared involved either adjacent teeth in the same patient or corresponding teeth on opposite sides of the same dental arch. Biopsy specimens were obtained, by means of trephine and block section, of twenty-one of these defects to permit microscopic evaluation at four, five, and eight months postoperatively. The biopsy material was fixed in 10 per cent formalin. Celloidin sections of decalcified specimens were prepared and stained with hematoxylin and eosin.

RESULTS

CASE 1.—A 21-year-old Negro Marine reported to the dental clinic at the Marine Corps Base, 29 Palms, California, on Jan. 6, 1959, with the complaint of "pain and swelling of the lower jaw." Oral examination revealed a swelling of the mucolabial fold opposite the mandibular central incisors. Roentgenograms demonstrated areas of periapical radiolucency involving the mandibular right central and lateral incisors and the mandibular left central incisor (Fig. 1, *A*). These three teeth failed to respond to stimulation by the electric pulp tester; all other teeth responded within normal limits. The root canals of the involved teeth were opened and drainage was established.

On Jan. 9, 1959, under local conduction and infiltration anesthesia, a one-stage root canal filling and periapical curettage was performed. The contents of the periapical areas proved microscopically to be radicular cysts. The areas of labial bone cortex destruction measured 8 mm. in the right lateral incisor, 7 mm. in the right central incisor, and 8 mm. in the left central incisor (Fig. 2, *A*). Boiled, defatted cortical heterogenous bovine bone was placed in the osseous defect of the right lateral incisor; the right central incisor served as a control and remained empty; and the left central incisor was implanted with ethylenediamine-treated heterogenous cortical bone (Fig. 2, *B*). Postoperative healing was uneventful.

Five months after surgery, radiographs showed slight evidence of the initial radiolucencies with the radiopaque osseous implant particles still visible in some areas (Fig. 1, *B*).

At this time, five months after the original surgery, the operative site was re-exposed by raising a labial mucoperiosteal flap. The labial cortex was found to have re-formed over all three defects (Fig. 2, *C*). Block sections of the labial cortex were removed for histologic examination (Fig. 2, *D*). These specimens demonstrated the existence of a thick cortical plate overlying all three defects (Fig. 3, *A*). Trabecular bone formation extended from the cortex toward the central portion of the defects. Haversian systems were seen throughout the regenerated labial plate (Fig. 3, *B* and *C*). Implanted bone chips were found to

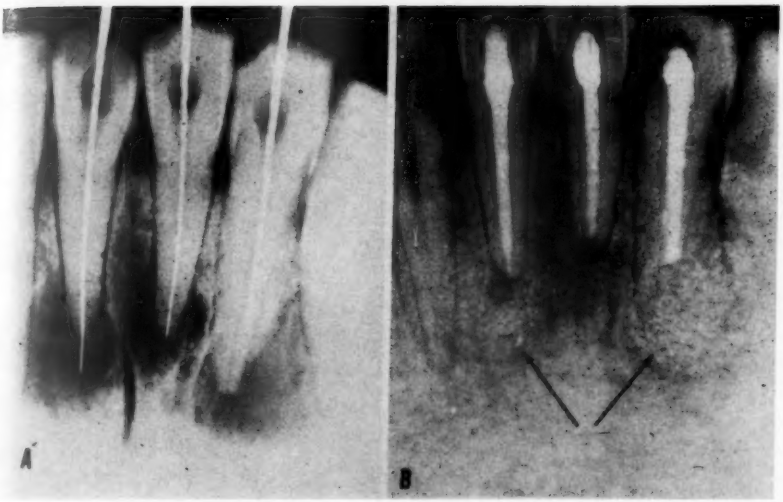
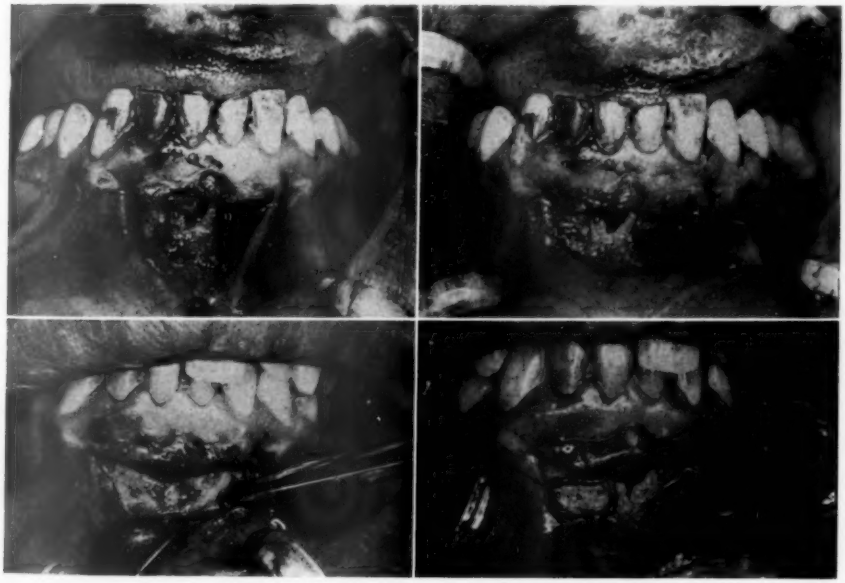


Fig. 1.—*A*, Three mandibular incisors with separate discrete areas of periapical radiolucency. Microscopically, these areas proved to be radicular cysts.

B, Five months postoperatively radiographic examination revealed evidence of residual radiopaque osseous implant particles (arrow).

A. *B.*



C. *D.*

Fig. 2.—*A*, Following periapical curettage, the area of labial cortex destruction measured 8 mm. in diameter in the right lateral incisor, 7 mm. in the right central incisor, and 8 mm. in the left central incisor.

B, Boiled, defatted heterogenous bone was placed in the osseous defect of the right lateral incisor, the right central incisor served as a control and was not implanted, and the left central area was implanted with ethylenediamine-treated heterogenous bone.

C, Five months after the original surgery, the operative site is re-exposed by raising a mucoperiosteal flap. The labial cortex can be seen to have re-formed over all three defects.

D, A block section of the labial cortex was removed for histologic examination.

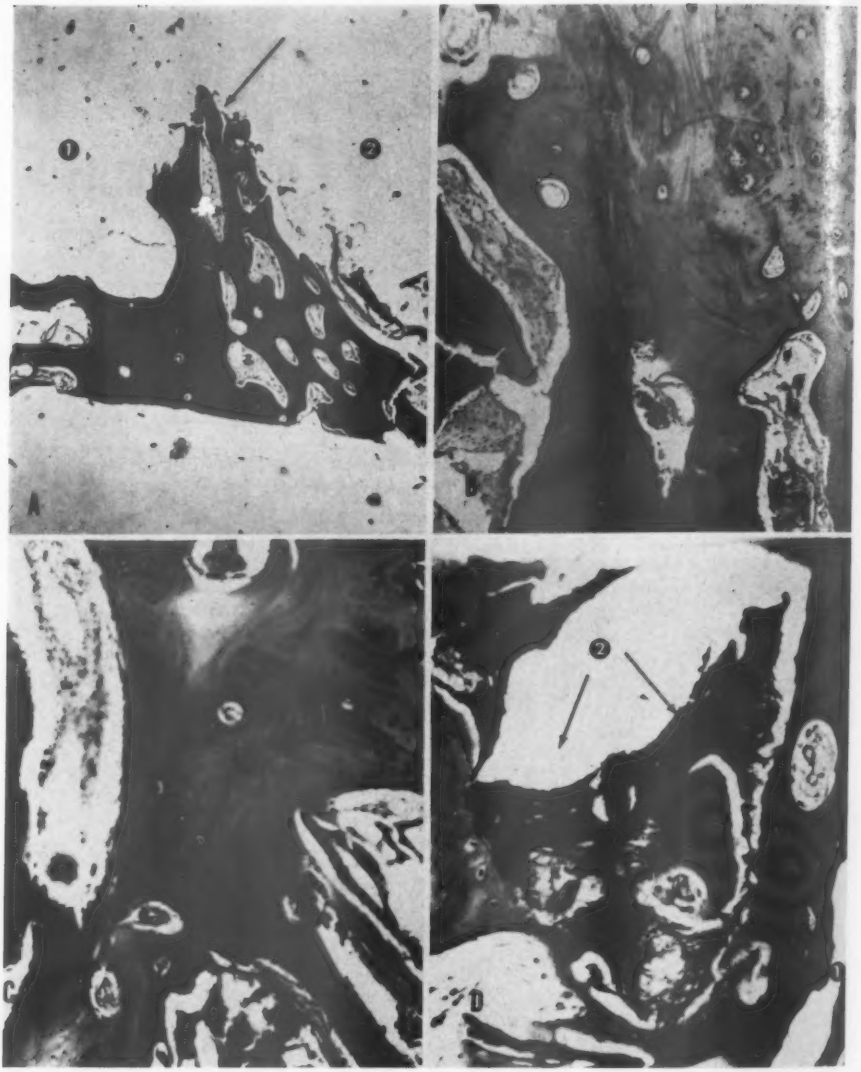


Fig. 3.—*A*, A labiolingual, hematoxylin-and-eosin-stained section of the specimen shown in Fig. 2, *D*. A septum (arrow) separated the control periapical bone defect *(1)* from the defect *(2)* which had been implanted with boiled, defatted bone. The labial cortex lies along the lower border of the specimen.

B, A mesiodistal section through the inner surface of the labial cortex overlying the control defect. Cortical bone has formed with characteristic Haversian systems.

C, A similar mesiodistal section through the labial cortex of the defect implanted with boiled, defatted bone. A remnant of an implant particle (arrow) has been surounded by host bone.

D, A section from another area of the same specimen reveals perivascular new bone *(1)* in the center of a heterogenous particle *(2)* which stains deeply basophilic.

be "embedded" within the bone cortex (Fig. 3, *C* and *D*). In some cases these implant particles were undergoing perivascular remodeling (Fig. 3, *D*). Particles lying within the soft tissue of the center of the defect exhibited lesser amounts of perivascular new bone formation.

CASE 2.—A 22-year-old white Marine reported to the dental clinic at the Marine Corps Base, 29 Palms, California, on Oct. 4, 1958, with the complaint of facial swelling. Oral examination revealed a swelling of the mucolabial fold opposite the maxillary central incisor. Radiographic examination revealed two large areas of periapical radiolucency involving the maxillary central incisors. Palliative treatment was instituted, and on Oct. 9, 1958, under local infiltration anesthesia, a one-stage root canal filling and periapical curettage

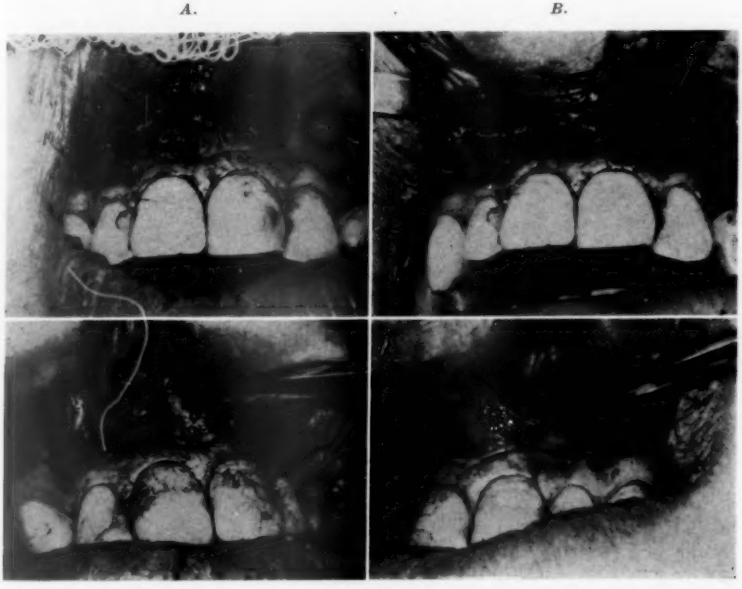


Fig. 4.—*A*, Periapical defects involving the central incisors in this case contained granulomas (arrows).

B, Following periapical curettage, the defect of the right central incisor measured 9 mm. and was not implanted. The defect of the left central incisor measured 10 mm. and was implanted with freeze-dried homogenous bone.

C, Following re-exposure of the operative site of the right central incisor five months after surgery, an area of fibrous connective tissue remained in this control labial cortex defect. At this time the defect measured 6 mm. in diameter.

D, The opposite central incisor defect which was implanted with freeze-dried homogenous bone measured 3 mm. in diameter upon re-exposure.

was performed. Two large masses of soft tissue were removed from the periapical areas (Fig. 4, *A*). These proved, upon microscopic examination, to be dental granulomas. Following curettage, the periapical labial plate destruction of the right and left central incisors measured 9 and 10 mm. in diameter, respectively (Fig. 4, *B*). The right central incisor served as a control and was not implanted; the left central defect was implanted with freeze-dried homogenous bone particles.

Five months after surgery, the operative site was re-exposed by elevation of the mucoperiosteum. An area of fibrous tissue remained in the unimplanted defect, which measured 6 mm. at the labial plate (Fig. 4, *C*). The left periapical defect, which originally had measured 10 mm. in diameter, measured 3 mm. at the time of re-exposure (Fig. 4, *D*).

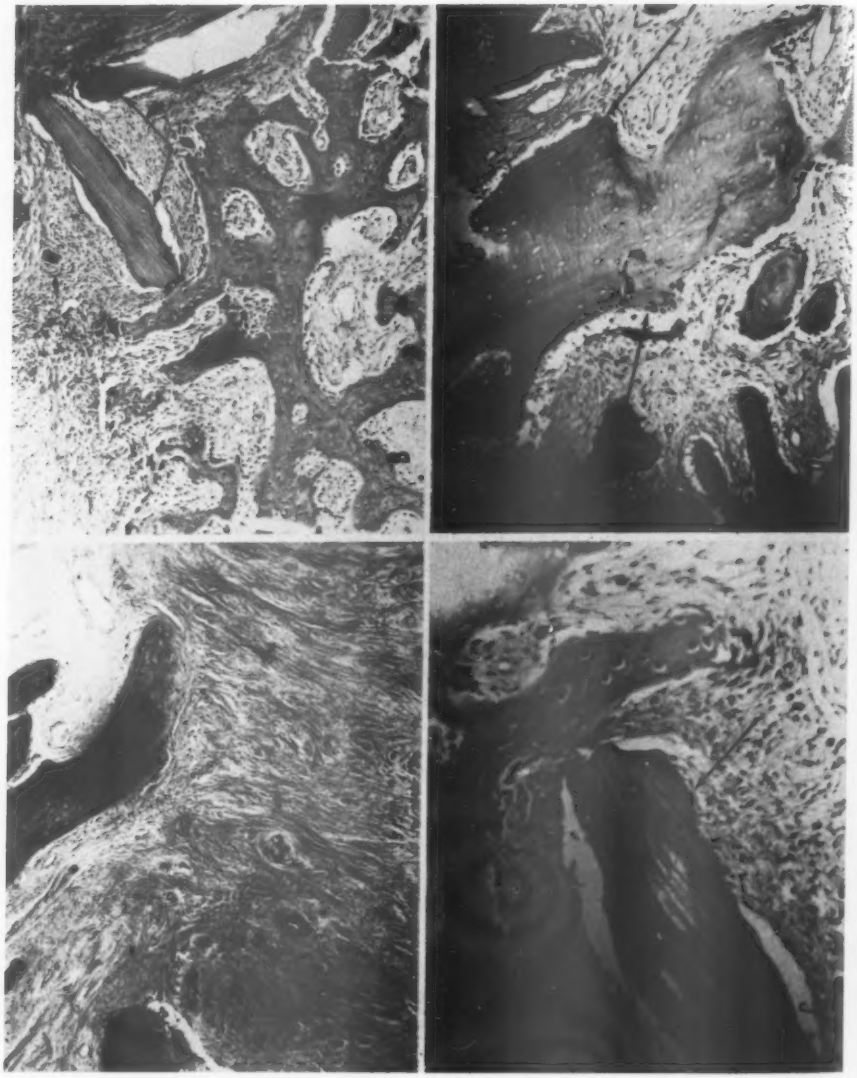


FIG. 5.—*(For legend, see opposite page.)*

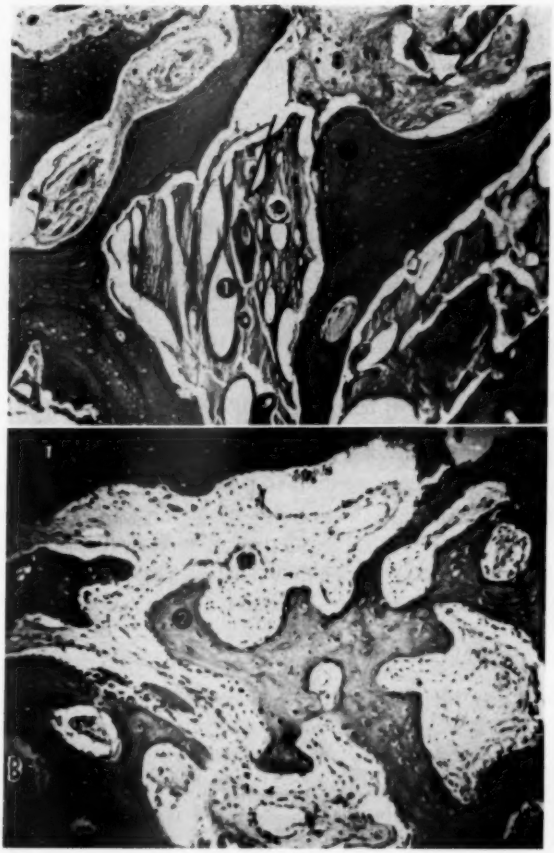


Fig. 6—*A*, A biopsy specimen taken from a periapical defect which had been implanted with ethylenediamine-extracted bone eight months previously. An implanted particle of ethylenediamine-treated bone *(1)* has been surrounded by host bone *(2)*. Limited perivascular new bone formation is present within the bone particle (arrow).

B, A specimen taken from the control unimplanted defect in the same patient exhibited labial cortex regeneration *(1)*, with trabecular bone *(2)* extending toward the center of the defect.

Fig. 5.—*A*, A biopsy specimen taken five months postoperatively from the control site shown in Fig. 4, *C*. Bone trabeculae have extended toward the cortical plate defect which is filled with dense fibrous connective tissue.

B, A specimen taken five months after implantation from the defect shown in Fig. 4, *D*. Newly formed bone trabeculae have extended into the defect from the periphery. Within the center of the defect, freeze-dried cortical bone particles (arrows) are apparently eliciting no osteoblastic activity.

C, A higher-power photomicrograph of the freeze-dried bone particle shown in Fig. 5, *B* illustrating the lack of osteoblastic activity surrounding the implant particle (arrow).

D, A biopsy specimen taken from a similar case eight months postoperatively. Host appositional bone (arrows) has formed along the margins of a freeze-dried bone particle in a manner similar to that observed surrounding heterogenous bone implants.

Fig. 5.—(For legend, see opposite page.)

Fibrous tissue occupied the residual defect of the labial plate. A histologic section of a trephined specimen taken from the control defect five months postoperatively showed newly formed trabecular bone filling the defects and extending to the as yet unrestored labial cortex (endosteal trabeculation) (Fig. 5, *A*). Periapical areas implanted with freeze-dried bone particles demonstrated osseous regeneration comparable to that formed in similar defects implanted with other osseous material. A histologic specimen of the implanted periapical defect taken five months postoperatively showed newly formed bone trabeculae extending toward the labial cortical defect. Within the center of the defect, freeze-dried cortical bone particles were apparently eliciting no osteoblastic activity (Fig. 5, *B*). Occasionally osteoclasts might be seen at the periphery of the particles. These implant particles were surrounded by fibrous connective tissue and some chronic inflammatory cellular elements (Fig. 5, *C*). Regeneration of the defect and re-formation of the labial cortex was apparently proceeding independently of the implant material. In other similarly implanted specimens taken from patients eight months postoperatively, host reactive bone was found to have surrounded the freeze-dried bone particles (Fig. 5, *D*).

In other cases of the series, particles of ethylenediamine-treated bone were found to be embedded in the host bone cortex of implanted defects in a manner similar to freeze-dried and boiled, defatted bone particles. In Fig. 6, *A* a particle of ethylenediamine bone situated in the regenerated labial cortex of the osseous defect shows remodeling in the form of perivascular new bone formation eights months postoperatively. Ethylenediamine bone particles located in the center of the osseous defect demonstrated limited reactive bone apposition eight months postoperatively. The control defect similarly demonstrated regenerated labial cortex and trabecular bone formation in the center of the defect (Fig. 6, *B*).

DISCUSSION AND CONCLUSIONS

It was not possible to predict accurately the degree of labial cortex healing by means of clinical and roentgenographic examination. These postoperative observations would support recent studies which indicate that clinical evidence of osseous healing of human alveolar bone defects is not necessarily reflected in the microscopic changes of the involved tissues.[6]

TABLE I. TIME OF RE-EXPOSURE

	(MONTHS POSTOPERATIVELY)			TOTALS
	4	5	8	
	5 to 8 mm. Defects			
Number of cases	1	3	0	4
Number of defects	2	8	0	10
	8 to 12 mm. Defects			
Number of cases	1	1	3	5
Number of defects	2	3	6	11

All periapical areas, both control and implanted, in which labial plate defects measured 5 to 8 mm. in diameter healed with complete re-formation of the labial bone cortex within five months postoperatively (Table I). Control periapical defects measuring 9 to 12 mm. in diameter at operation demonstrated limited labial cortex formation (Fig. 5, *A*), and central cores of dense, avascular

fibrous connective tissue exhibiting no appreciable osteogenic activity remained in the cortical defects eight months after surgery (Table I). It is entirely possible that further healing of these defects would result in the replacement of this core of fibrous connective tissue by host bone,[7] with the complete reformation of the labial cortex resulting in a fully healed bone defect. The implanted defects in such cases demonstrated more labial cortex formation when compared with the unimplanted controls.

It would appear that in small periapical bone defects involving labial plate destruction there is a tendency toward regeneration of the cortical portion of the bone. This study suggests the possibility of effecting, in larger periapical areas, regeneration of the cortical portion of the bone by the use of osseous implant materials. Recent studies[8] have indicated that implanted bone chips, by virtue of their mass and surface area, may serve to prevent the overlying soft tissues of the mucoperiosteum from collapsing into the osseous defect. The implanted particles may provide a potential space within which new bone may develop.[8] Although microscopic observation of specimens from these areas revealed that the implanted bone particles were apparently playing no active role in the dynamic process of bone healing, the implant material may serve as a passive participant in the osteogenic process by providing a trellis of surfaces through which new host bone may form. It would appear that the host tissue responses of periapical alveolar bone to the three types of osseous materials used in this study are histologically similar.

SUMMARY

1. Twenty-one periapical defects in nine adult human patients were examined postoperatively by the technic described.

2. The ten defects (control and implanted) which at operation measured 5 to 8 mm. in diameter healed with complete regeneration of the labial bone cortex within five months after curettage.

3. The eleven periapical defects measuring 9 to 12 mm. in diameter exhibited a more limited labial cortex formation eight months after surgery.

4. While the implantation of boiled, defatted, and ethylenediamine-extracted heterogenous bone, or freeze-dried homogenous bone did not appear to have actively influenced the nature of the host bone trabeculation of the intraosseous defect, the implanted material appeared to have passively assisted the osteogenic process.

CONCLUSION

1. The results of this study would suggest that the early regeneration of alveolar cortex is an important aspect of the healing processes operating in periapical bone defects.

2. The formation of dense, avascular, fibrous connective tissue in areas of periapical cortical bone loss appeared to be influenced by the initial size of the defect and the presence or absence of compatible osseous implant material.

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ANNOUNCEMENTS

American Academy of Oral Pathology

The Academy will hold its fifteenth annual meeting at the School of Dentistry, University of Michigan, Ann Arbor, Michigan, April 6 to 8, 1961. Examination for elevation to Fellowship will be held in the Pathology Building at 9 A.M. on April 6. The scientific session will be held on April 7 in the Basic Science Building. The third annual Helen McLain Lecture, "Rudolph Virchow—Statesman, Anthropologist, and Father of Cellular Pathology," will be given by Dr. Harold A. Oberman of the University of Michigan. The annual symposium will be held on April 8.

Interested guests are advised to contact Dr. Robert J. Gorlin, Professor and Chairman, Oral Pathology, School of Dentistry, University of Minnesota, Minneapolis 14, Minnesota.

Pacific Coast Oral Pathology Association

The Association announces that the annual Oral Pathology Workshop, Conference, and Seminar will be held on April 15, 1961, at the Letterman General Hospital in San Francisco, California. The theme of the Workshop will be "Disturbances of the Salivary Glands," and Dr. S. N. Bhaskar will serve as moderator. Dr. Daniel A. Collins is program chairman.

The registration fee of $20.00 includes microscopic slides, luncheon, and literature.

For details and registration, write Dr. R. Gordon Agnew, Executive Secretary, Pacific Coast Oral Pathology Workshop, University of California Medical Center, San Francisco 22, California.

Balint Orban Memorial Seminar

The Seminar (formerly known as the Rocky Mountain Dental Seminar) will be held in Boulder, Colorado, June 25 to 28, 1961. The theme for the Seminar is "Clinical and Microscopic Pathology of the Periodontium and Other Oral Structures." The outstanding group of essayists includes Drs. S. N. Bhaskar, Henry Goldman, Maynard K. Hine, and Harry Sicher.

Further details and application may be obtained by writing to Mrs. James Manella, Secretary, Balint Orban Memorial Seminar, 1700 Mesa Rd., Colorado Springs, Colorado.

American Academy of Dental Medicine

The Academy will hold a cruise convention aboard the luxury liner *S. S. Ocean Monarch* to Bermuda and Nassau over the Memorial Day week end, May 26 to June 3, 1961, combining a comprehensive scientific session with a program of recreation.

The theme of the scientific program is "Recent Trends in Dental Medicine." Lectures will be given by Hermann Becks, Professor of Oral Biology, University of California School of Dentistry; J. Lewis Blass, Professor of Periodontia and Oral Medicine, New York University College of Dentistry; and Milton Hyman, Professor of Oral Diagnosis and Roentgenology, New York University College of Dentistry. Two symposiums will be conducted by members of the various sections of the Academy.

While in Bermuda members of the Academy will be guests of the Bermuda Dental Society at a buffet dinner-lecture. Dr. Hermann Becks, President of the Academy, will address the joint meeting.

Superb service and cuisine, nightly dancing and entertainment, sight-seeing, and sports activities will be included in the recreational program.

All interested dentists and physicians, as well as Academy members and their families, are welcome. For details and reservations, address Dr. Howard Ward, General Chairman, 15 Bond St., Great Neck, New York.

Twelfth Annual Berkshire Conference

Tufts University School of Dental Medicine announces that the twelfth annual Berkshire Conference in Periodontology and Oral Pathology will be held at Eastover, a resort hotel in the Berkshire Mountains in Lenox, Massachusetts, Sunday through Thursday, June 18 to 22, 1961. The theme of the Conference will be "The Current Clinical Significance of Developments of the Past Twelve Years." The faculty and curriculum will be as follows:

JOSEPH L. BERNIER, Major General, DC, USA, Assistant Surgeon General and Chief of the Dental Corps. "Developments in the Understanding of Malignancy as They Relate to the Diagnosis and Treatment of Oral Lesions."

IRVING GLICKMAN, D.M.D., Research Professor of Oral Pathology, Professor and Chairman of the Department of Periodontology, Tufts University School of Dental Medicine, Boston, Massachusetts. "The Status of Periodontics and the Problems It Presents."

SIGURD RAMFJORD, L.D.S., PH.D., Professor of Periodontology, The University of Michigan, School of Dentistry, Ann Arbor, Michigan. "A Step-by-Step Procedure for the Treatment of Temporomandibular Joint Disturbances by Occlusal Correction."

JOHN B. MACDONALD, D.D.S., M.S., PH.D., Director, Forsyth Dental Infirmary; Professor of Microbiology and Director of Postdoctoral Studies, Harvard School of Dental Medicine, Boston, Massachusetts. "Bacteria and Enzymes: Their Significance in the Etiology and Treatment of Periodontal Disease."

FRANK WENTZ, D.D.S., M.S., Professor of Periodontology, Loyola University, Chicago, Illinois. "Muco-Gingival and Bone Surgery: Their Objectives, Advantages, and Limitations in the Treatment of Periodontal Disease."

SEYMOUR KRESHOVER, D.D.S., PH.D., M.D., Assistant Director of the National Institute for Dental Research, National Institutes of Health, Bethesda, Maryland. "Systemic Factors: Their Significance in the Etiology and Treatment of Periodontal Disease."

FINN BRUDEVOLD, L.D.S., D.D.S., M.S., Chief of Dental Medicine, Forsyth Dental Infirmary; Professor of Dentistry, Harvard School of Dental Medicine, Boston, Massachusetts. "Research Advances in the Mechanism of Calculus Formation and Their Potential Clinical Application."

DAVID WEISBERGER, D.M.D., M.D., Professor of Dental Medicine, Harvard School of Dental Medicine; Oral Surgeon and Chief of Dental Service, Massachusetts General Hospital, Boston, Massachusetts. "The Topical and Systemic Use of Drugs in Gingival and Other Oral Mucous Membrane Diseases."

EVERETT SHAPIRO, D.M.D., Associate Clinical Professor and Chairman of the Department of Orthodontics, Tufts University School of Dental Medicine, Boston, Massachusetts. "Orthodontic Procedures in the Management of Periodontal Problems."

For further information and application, write to Tufts Berkshire Conference, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston 11, Massachusetts.

University of Alabama

The School of Dentistry will offer the following courses during the month of May, 1961:

Pedodontics for the General Practitioner. May 6 and 7. Sidney B. Finn, D.M.D., M.S.

Root Canal Therapy Followed by Apicoectomy. May 10 to 12. Adeeb E. Thomas, D.M.D.

Surgical Anatomy of the Head and Neck. May 22 to 24. Harry Sicher, M.D., D.Sc.

Albert Einstein College of Medicine
Yeshiva University

The Department of Dentistry announces the following postgraduate courses:

Anesthesiology DPD 11—Pre-medication, Co-medication, and Supportive Therapy in Dental Practice. April 6 and 7, 1961. Dr. Stanley R. Spiro and associates. $60.00.

Anesthesiology DPD 19—Preoperative and Pre-Anesthetic Evaluation Techniques for All Dental Patients. June 9, 1961. Dr. Stanley R. Spiro and associates. $30.00.

Endodontics DPD 22. Feb. 22 to 24, 1961. Dr. Julius Fox and associates. $100.00.

Dento-Alveolar Surgery DPD 33. May 4 and 5, 1961. Drs. Herbert Calman, Stanley J. Behrman, William Rakower, and associates. $50.00.

Oral Pathology and General Practice DPD 27. March 24 and 31, 1961. Dr. Ernest Baden. $50.00.

Advanced Oral Pathology DPD 29. Three consecutive days, December, 1961. Dr. Ernest Baden and associates. $75.00.

Periodontics DPD 66. Ten Wednesdays, March 1 through May 3, 1961. Drs. Marvin N. Okun, Irving Yudkoff, and associates. $225.00.

Periodontics DPD 69. Oct. 30 to Nov. 3, 1961. Drs. Irving Yudkoff, Marvin N. Okun, and associates. $175.00.

Prosthodontics DPD 77—Full Denture Construction. Friday mornings, March 3 to 31, 1961. Drs. Lester E. Rosenthal and Max A. Pleasure. $75.00.

For further information and application blanks about specific postgraduate courses, write to Director, Postgraduate Dental Division, Albert Einstein College of Medicine, Yeshiva University, Eastchester Rd. and Morris Park Ave., Bronx 61, New York.

New York University College of Dentistry

The Department of Periodontia announces that a one-day course in "The Uses of Ultrasonics in Periodontal Therapy" will be given on Friday, April 14, 1961, from 9:30 A.M. to 5:30 P.M. The course, designed to acquaint the general practitioner with the scientific principles and clinical uses of ultrasonic vibrations in periodontal therapy, will be directed by Dr. Sidney Sorrin, assisted by Drs. N. Alderman, A. Arvins, S. J. Ewen, M. J. Pomeranz, M. Simring, and S. S. Stahl.

Applications for the course may be obtained by writing to Director, Postgraduate Division, New York University College of Dentistry, 421 First Ave., New York 10, New York.

University of Pennsylvania

The School of Dentistry announces the following postgraduate courses:

Practical and Simplified Procedures in Crown and Bridge Prosthesis. March 13 to 17, 1961. Charles B. Sceia.
Complete Denture Prosthesis. March 27 to 30, 1961. Vincent R. Trapozzano.
Endodontics. April 10 to 21, 1961. Louis I. Grossman and associates.
Minor Tooth Movement and Temporary Stabilization. April 12 to 14, 1961. Leonard Hirschfeld.
Complete Denture Prosthesis. April 17 to 21, 1961. M. M. DeVan and associates.
Function—Prime Object of Dentistry. April 24 to 28, 1961. Arne G. Lauritzen.

The twelfth Mid-Atlantic States Conference on Dentistry will be held at Buck Hill Falls, Pennsylvania, April 16 to 21, 1961. The theme of this year's conference is "Current Clinical Practices," and essayists will be H. J. Bartelstone, D. Walter Cohen, Orville B. Coomer, S. Howard Payne, Samuel Seltzer, and Robert B. Shira.

For further information, please write Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce St., Philadelphia 4, Pennsylvania.

University of Puerto Rico

The Postgraduate Education Division of the University of Puerto Rico School of Dentistry announces that it is sponsoring a postgraduate course in periodontology from June 4 to 9, 1961. The entire course will be given in Spanish, making it of prime interest to all the Spanish-speaking members of the dental profession. The course will be directed by Dr. Claudio Funcia Cornell. Dr. Funcia is a member of the A.R.P.A., the American Academy of Periodontology, the American Society of Oral Surgeons, and the American Academy of Oral Pathology, as well as a Fellow of the American College of Dentists.

Further information may be obtained from Rafael Aponte, Jr., D.D.S., Director Postgraduate Education, University of Puerto Rico School of Dentistry, San Juan 22, Puerto Rico.

University of Rochester School of Medicine and Dentistry

Applications for the following positions are invited:

Resident in Oral Surgery (Chief)
Stipend, $3,400.00 per year.
Assistant Resident in Oral Surgery
Stipend, $3,200.00 per year.
Rotating Intern (two positions)
Stipend, $3,000.00 per year.

One-year appointments will be effective July 1, 1961.

For detailed information and application forms, write to Dr. Erling Johansen, Chairman, Department of Dentistry and Dental Research, University of Rochester, School of Medicine and Dentistry, Rochester 20, New York.

Temple University Dental Alumni Society

The Society will hold its ninety-seventh annual reunion on May 3, 1961. A full day of informative clinics is planned, to be climaxed with a dinner in the evening.

For further information, write to Temple University Dental School, 3223 North Broad St., Philadelphia, Pennsylvania.

Mount Sinai Hospital of New York

The Department of Dental and Oral Surgery announces that a meeting will be held jointly with the Jewish Chronic Disease Hospital of Brooklyn at 8 P.M. on Wednesday, March 15, 1961. The meeting will be held in the surgical amphitheater of Mount Sinai Hospital, 100th St. and 5th Ave., New York, New York. The following subjects will be discussed:

1. Endodontic Therapy for the Chronically Ill. Dr. Joseph Obst.
2. Carcinoma of the Palate. Dr. Sidney Kupfer.
3. Operative Management of Mandibular Prognathism. Dr. Walter Caruso.
4. An Interesting Case Report: Clinical Pathological Presentation. Dr. Melvin Blake.

Members of the profession are welcome.

Norfolk General Hospital

The Department of Dentistry is now accepting applications for a mixed internship, with emphasis on oral surgery and periodontia, that will begin July 1, 1961. Applications should be addressed to Dr. Thomas G. Warrick, Secretary, Department of Dentistry, Norfolk General Hospital, Raleigh Avenue, Norfolk, Virginia.

University of Pennsylvania

Research and teaching traineeships in the basic sciences, in periodontology, and in the comprehensive treatment and rehabilitation of the cleft palate patient are available at the School of Dentistry, University of Pennsylvania.

Candidates for the traineeships in the basic sciences must qualify for admisson to the Graduate School of Arts and Sciences. These traineeships may lead to M.S. or Ph.D. degrees.

The traineeship in periodontology is a two-year program devoted to basic science studies, clinical practice, and research.

The traineeship in the comprehensive treatment and rehabilitation of the cleft palate patient is clinically oriented; however, opportunities for course work in fields related to cleft palate therapy are available.

All traineeships are supported by the United States Public Health Service. Annual stipends vary from $4,500.00 and up, depending on the qualifications and needs of the successful candidates. Inquiries concerning the basic science and cleft palate traineeships should be sent to the Chairman, Committee on Traineeships and Fellowships, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pennsylvania. Inquiries concerning the traineeships in periodontology should be sent to Dean, Graduate School of Medicine, 237 Medical Laboratories, University of Pennsylvania, Philadelphia 4, Pennsylvania.

Northeastern Society of Periodontists

The Society will hold its spring meeting on April 7, 1961, at the Park Sheraton Hotel in New York City. Drs. Charles Bassett, Irwin Clark, and Karl Meyer of Columbia University will lecture on "Some Current Aspects of Bone and Connective Tissue."

Further information may be obtained from the secretary, Dr. Irwin W. Scopp, Veterans Administration Hospital, First Avenue at East Twenty-fourth Street, New York 10, New York.

REVIEWS OF THE LITERATURE

BOOK REVIEW

Tumors of the Odontogenic Apparatus and Jaws. Joseph L. Bernier, D.D.S., M.S., F.D.S. R.C.S. (England), Major General, DC, USA. Section IV, Fascicle 10a, of *Atlas of Tumor Pathology.* Published by the Armed Forces Institute of Pathology, Washington, D. C. 107 pages; 120 illustrations. Price, $1.00.

Here is a collection of very interesting tumors from the files of the Armed Forces Institute of Pathology and the Registry of Oral Pathology of the American Dental Association. The cases include lesions of the odontogenic apparatus. Cysts of all types, as well as tumors, are described on the basis of an accepted useful classification. Nonodontogenic tumors, benign and malignant, are to be considered in the making of a differential diagnosis, as are such skeletal diseases as Paget's disease of bone, eosinophilic granuloma, myeloma, Ewing's sarcoma, and osteogenic sarcoma.

Various lesions of the oral mucosa and tongue are illustrated by means of excellent color plates. The natural history, clinical manifestations, and microscopic findings are dealt with, making this atlas of great value to the clinician as well as the pathologist.

K. H. T.